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Polyethylene Oxide Condensates, an Aid in the SPECTROPHOTOMETRY OF DYESTUFFS

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(A Contribution from the Research Laboratory of Sidney Blumenthal & Co., Inc.)

A CONSIDERABLE number of polyethylene oxide condensates are recommended for a variety of uses in textile processing. When used in connection with the application of dyestuffs, their value is stated to be due to their characteristic property of forming unstable addition compounds with dyes (in solution) rather than to any affinity for the fiber (Ref. 2). Valko (Ref. 6) showed by diffusion measurements on Sky Blue FF (C. I. No. 518) that the resulting aggregates are definitely larger colloids than the pure dye.

We have found that the addition of compounds of this type to dyestuff solutions has the effect of stabilizing the solution so that more accurate spectrophotometric analysis and more reproducible results can be obtained. Furthermore, by this procedure, it is possible to determine with equal accuracy, the composition of solutions containing a mixture of dyestuffs, which would otherwise interact in solution giving rise to gross errors in estimation.

USE WITH ORDINARY WATER SOLUBLE DYES

In evaluation of dyestuffs strength from water solution data with the G. E. Recording Spectrophotometer, it is common practice to select a concentration of dye such that the transmittance of a 10 mm. thickness at maximum absorption is about 20 per cent. This concenration figure varies generally between 0.001 per cent and 0.008 per cent for the usual commercial water soluble dyes. Measurement of these dilute solutions is notoriously subject to errors which arise from their susceptibility to variations in pH, salt concentration, irradiation, ambient temperature, dissolving temperature, aging, etc.

The solution which is presented for spectrophotometric examination is usually prepared by a standardized procedure and buffered to a pH value which has been predetermined to be most stable to variables such as irradiation, aging, and small pH differences. A typical case of the effect of pH on dye solutions is shown in Figure 1. Here a range of pH values* is exhibited which strongly affect the color of Diamine Fast Red F (C. I. No. 419). In order to determine which is the most desirable pH value at which to buffer the solution, such a set of solutions is prepared and examined using two criteria: small pH differences and aging. The first choice would be to buffer the solution at pH 7.5 since there is no change after 24 hours aging. The pH 10 solution shows a very small loss in strength (1.5 per cent), but the pH 4.6 solution is partially decolorized before its first measurement and has lost another 5 per cent when remeasured after 24 hours.

If, however, about 0.2-1 per cent of the final volume of a nonionic type of polyethylene oxide condensate (herein referred to as *P.E.O.C.)* is added to the spectral solution, these errors are reduced to a minimum.

There are several other phenomena exhibited in Figure 1 that are worthy of note. This dye is subject to a considerable salt effect which is overcome when the P.E.O.C. is added and these solutions show excellent aging characteristics. There is no difference at maximum absorption with variation of the pH of the buffer, and any one of these solutions could be chosen for its good aging properties.

It will also be noted on Figure 1 that there is a decided bathochromic shift with P.E.O.C. This color change is generally accompanied by an increase in colori-

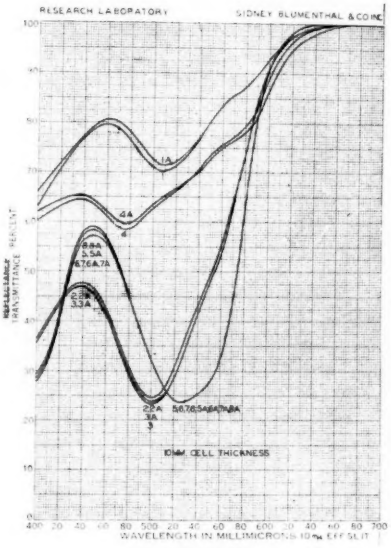

FIGURE NO. 1

Stability Improvement with a P.E.O.C.
0.002% Diamine Fast Red F
(C. I. No. 419)

Curve No.	*Buffer pH*
	(Original Measurement)
1	4.6
2	7.5
3	10.0
4	None, 1% NaCl
5	4.6 + 1% P.E.O.C.
6	7.5 + 1% P.E.O.C.
7	10.0 + 1% P.E.O.C.
8	None, 1% NaCl + 1% P.E.O.C.

"A" Curves—remeasurement of above solutions, after 24 hrs. aging.

*Note

The concentration of the buffer mixtures used in this work is:

pH 4.6 — 0.63 g. Glacial Acetic Acid, 0.20 g. Sodium Hydroxide, Per liter of dye solution, Ref. 3, Table 49A, p. 219

pH 7.5 — 0.333 g. Sodium Hydroxide, 0.136 g. Potassium Dihydrogen Phosphate, Per liter of dye solution, Ref. 3, Table 35, p. 200

pH 10.0 — 0.320 g. Sodium Carbonate, 0.375 g. Borax Crystals, Per liter of dye solution, Ref. 3, Table 46, p. 215

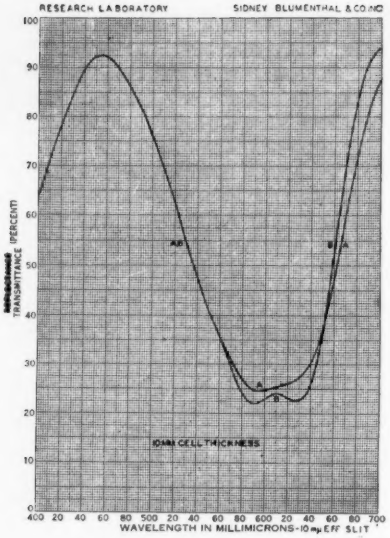

FIGURE NO. 2
Appearance of Secondary Absorption
0.006% Alizarine Sky Blue B
(C. I. No. 1088)
Curve "A"—without P.E.O.C.
Curve "B"—with 1% P.E.O.C.
pH 7.5 Buffer

metric purity (hyperchromic change). Certain dyes such as Alizarine Sky Blue B (C. I. No. 1088) Figure 2, show the development of a second absorption band (with the resolution of the G. E. Spectrophotometer at 10 mμ. effective slit width) when a P.E.O.C. is present. A bathochromic effect takes place with most dyes in presence of a P.E.O.C. but there are important exceptions to this, such as Diamine Fast Orange ER (Prototype No. 73-Ref. 1) which shows a hypsochromic effect or Alizarine Sapphire B (C. I. No. 1054) where the effect is practically negligible. The effect of P.E.O.C. on solutions of many other soluble dyestuffs has been studied and each is characteristically affected. These phenomena can serve as a stamp useful in confirming chemical identity of two dyes.

USE WITH OTHER TYPES OF DYES

It is known that most P.E.O.C.'s have excellent dispersing properties and consequently find use in preparing acetate dyes for determination on the spectrophotometer. We add 5 per cent (by volume) of a P.E.O.C. to the dry dye when preparing the master dispersion and the usual 1 per cent to the diluted spectral dispersion. The resulting preparation seems to have all the desirable properties of a water-soluble dye with regard to stability.

Vat dyes can be brought into water solution by chemical reduction with sodium hydroxide and sodium dithionite. The leuco solutions of a few of the vat dyes are sufficiently stable (if kept in a stoppered bottle) to render them suitable for determination by spectral means. However, it has been found necessary to add P.E.O.C. to the solution of most dyes so that the reproducibility and aging (24 hrs.) properties are good. We have found that all but two dyes out of some forty-five so far studied can be prepared by a common procedure: reduce the dye in a volumetric flask at 60° C. in a thermostatic bath with sodium hydroxide and sodium dithionite (hydrosulfite) in about one-quarter of the final volume. The concentration of the dye is governed by pipetting an aliquot from a water dispersion of the vat pigment; the concentration of the reductants is adjusted in the reducing bath to give a final concentration of 1.0 per cent sodium hydroxide and 1.2 per cent sodium dithionite; a P.E.O.C. is added just before making up to the mark with cold water. The flask contents is then transferred to a rubber stoppered bottle and shaken. The reproducibility of this method is good and the standard deviation for no dye exceeds 2½ per cent concentration.

Cropper and Giles (Ref. 4) pointed out that Naphthols could be determined colorimetrically if properly coupled with diazo sulfanilic acid and the resulting monoazo dye dissolved in a 50 per cent alcohol solution. Certain P.E.O.C.'s are good assistants for improving coupling speed, aging qualities and reproducibility.

FIGURE NO. 3
Non-additive Dye Mixture
Curve A —0.0025% Diamine Sky Blue FF (C.I. No. 518)
Curve B —0.0025% Chrysophenine (C.I. No. 365)
Curve A + B—Mixture containing: 0.0025% Diamine Sky Blue FF (C.I. No. 518) 0.0025% Chrysophenine (C.I. No. 365)
Curve T —Theoretical curve calculated from the product of the transmittances of "A" and "B."
pH 7.5 Buffer

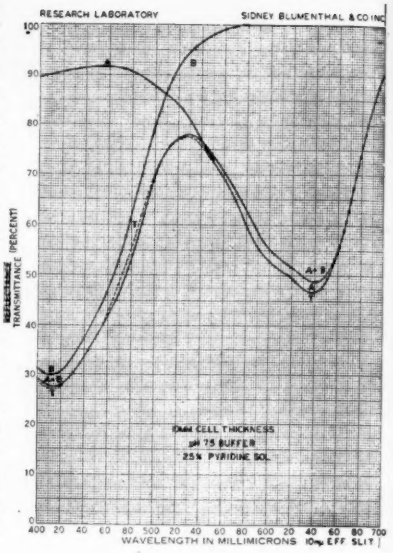

FIGURE NO. 4
Non-additive Dye Mixture with Pyridine
Curves—Same as shown in Figure No. 3 except that the solvent is 25% Pyridine.
pH 7.5 Buffer

USE IN NON-ADDITIVE DYE MIXTURES

The determination of mixtures of dyes in solution is frequently complicated by the serious problem generally termed "non-additivity." This phenomena is discussed by Neale and Stringfellow (Ref. 5) who proposed using a 25 per cent pyridine

FIGURE NO. 5
Non-additive Dye Mixture with a P.E.O.C.
Curves—Same as shown in Figure No. 3 except that 1% P.E.O.C. has been added to the solutions.
pH 7.5 Buffer

solution to avoid dye interaction. We have studied this to some extent and find that P.E.O.C. is quite effective in producing results which are practically quantitative. Using an example cited in the above mentioned paper, Figure 3 shows the impossibility of a calculation of the concentration of either component of the dye mixture. The results with 25 per cent pyridine solution, Figure 4, while a great improvement over a simple water solution, still show a slight bathochromic shift and an apparent error of 6 per cent in determination of the strength of the blue component. (The mixture curve "A + B" should of course, coincide exactly with "T" as well as "A" in the region of 560 to 700 mμ.) On the other hand, in Figure 5 where a P.E.O.C. has been used, it will be seen that the "A + B" curve actually coincides exactly with the "T" curve.

Equally good results have been obtained with all other normally non-additive combinations studied. P.E.O.C.'s also have simple technique advantages over 25 per cent pyridine, since they are much more easily handled and have practically no odor.

CONCLUSION

Our investigations into the action of P.E.O.C.'s on dyestuffs are not complete. Thus far, these materials have proven to be somewhat of a panacea to a large number of the ills common to the field of dyestuff determination by spectral means. An involved explanation of the mechanism of these phenomena is beyond the scope of this paper.

ACKNOWLEDGMENT

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A METHOD OF DETERMINING ORGANICALLY COMBINED SULFURIC ANHYDRIDE IN SURFACE-ACTIVE PRODUCTS

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SINCE the content of organically combined sulfuric anhydride in a surface-active product is the best indicator of its value as such, it is becoming increasingly necessary to find a method of determining that quantity. Present methods do not satisfactorily lend themselves to determining it on every type of product. The acid-titration method of determining organically combined SO_3 by the increase in acidity upon boiling with a known quantity of sulfuric acid is applicable to only those products which split off their combined SO_3 upon boiling with the acid. The ash-gravimetric method, adopted as standard by the AATCC[1], and ASTM[2], in which the undecomposed sulfonated matter is extracted over an acidulated concentrated salt solution and ashed, is applicable to sulfonated as well as sulfated products, but only in ordinary cases. In extracting some of the highly sulfonated oils, sulfated alcohols, and sulfonated fatty acid amides large amounts of salt are often carried over. Hart's method[4], based upon the conversion of the respective compounds into their ammonium salts and determining the ammonia in the latter, is the only method described in the literature which is applicable to all types of products, but is possibly more complex and involved than the following wet-ash gravimetric procedure.

The wet-ash gravimetric method described in this paper is applicable to every type of surface-active product. In addition to the official ash-gravimetric method it has the advantages of being wet-ashed instead of ignited, and any error due to salt carried over in the extraction process is eliminated in the subsequent precipitation of the sulfate. That wet-ashing with perchloric and nitric acids is a thoroughly reliable method for oxidation of organic matter and complete recovery of sulfates thereof is shown in work done by Toepfer and Boutwell[5], Kemmer and Boutwell[5], Smith, Frederick and Deem and Garrell[7], and Gieseking, Snider and Getz[8].

EXPERIMENTAL

For the most reliable means of checking values of organically combined sulfuric anhydride obtained by the wet-ash gravimetric method, several well known commercial products were selected for their adaptability to the official acid-titration method. For those products which did not adapt themselves to the acid-titration method and thus allow for further comparison, extremely close checks in duplicates tend to speak for themselves as to the feasibility of the method.

For the determination of organically combined SO_3 by an increase in acidity upon boiling with 1 N H_2SO_4, the method was followed as given in AATCC Handbook[3].

For the determination of organically combined SO_3 by a gravimetric method, the following experimental method was used:

A one gram sample of the oil was weighed and poured directly into a 500 ml. separatory funnel containing about 25 cc. of ethyl ether, or the solvent which most completely dissolved the oil. Using a saturated solution of c. p. sodium chloride, the oil was washed free of inorganic sulfates. This operation usually required three successive portions of the solution, and care had to be taken that the two phases were completely separated. The oily layer was transferred to a 500 ml. Kjeldahl flask and placed on a steam bath to evaporate to dryness.

10 cc. conc. nitric acid was added with care, and when the initial reaction was over, the sample was evaporated to almost dryness on a steam bath. 10 cc. more conc. nitric acid was added with 5 cc. 70 per cent perchloric acid and some glass beads. With a small Bunsen flame this was boiled until the solution became clear and light-straw colored. When necessary, 5 cc. additional perchloric and nitric acids were added. Careful attention must be given this ashing process to avoid over heating as this often causes ignition and a loss of sample.

After filtering, the sulfate was precipitated as barium sulfate in the usual manner[9] and calculated to SO_3.

Duplicate results may be obtained on any sample within six to eight hours. The minimum approximate time allows an hour for weighing and washing of sample, an hour for ashing, an hour for filtering and precipitating, two hours for standing of precipitate, and an hour for filtering, igniting, and weighing precipitate.

EXPERIMENTAL RESULTS:

TABLE 1

Sample Tested	Solvent Used	Per Cent Organically Com. SO_3 Titrimetric Method	Gravimetric M.
Sulfonated Vegetable Oil #1	Ethyl Ether	3.11	2.82
Sulfonated Vegetable Oil #2	Carbon Tetrachloride	2.47	2.38
Sulfated Fatty Ester #1	Ethyl Ether	8.56	8.73
Sulfated Fatty Ester #2	Ethyl Ether	6.62	6.86
Long Chain Fatty Alcohol Sulfate	Ethyl Ether	6.63	6.42
Sodium Alkylaryl Sulfonate	Ethyl Ether	6.97	6.90
Ether Sulfonate	n-Butanol	2.36	2.35
Sulfonated Mineral Oil	Petroleum Ether	4.71	4.75

1. To determine quantitatively the recovery of sulfates, a know amount of sulfate was added to sulfate free oleic acid and wet-ashed. Tabulated results show that even with small samples entirely satisfactory recovery was effected.

Amt. of Na_2SO_4 Added	Amt. of Na_2SO_4 Recovered	Difference
.1388 g.	.1405 g.	.0017 g.
.3599 g.	.3563 g.	.0036 g.
.3204 g.	.3237 g.	.0033 g.
.1769 g.	.1780 g.	.0011 g.

2. Since in ashing samples of sulfonated mineral oil ignition invariably took place, it was necessary to eliminate some of the free oil before a satisfactory wet-ashing could be obtained. This was successfully done according to a method described by Koch[6] in which the sodium sulfonate was selectively adsorbed onto Attapulgus clay from naptha solution and then was displaced from the adsorbent by methanol.

DISCUSSION AND SUMMARY

The application of this method offers no particular difficulties in examining all types of surface-active organic sulfates and sulfonates. In the authors' opinion one step stands out as the key to the successful use of this method, and that is the selection of the most suitable solvent to take up the substance in question as it is salted out. Thus a preliminary examination is desirable when the nature of the surface-active material is unknown.

The time required for analysis may undoubtedly be shortened by employing one of the conventional titrimetric methods for inorganic sulfates. The gravimetric procedure was used in the above work because the investigators found it gave greatest accuracy.

The extraction-wet-ash method as described is applicable to all types of sulfated and sulfonated substances, especially those related to textile processing.

This is not the case with the present standard methods for determining organically combined sulfuric anhydride since they are limited principally to sulphated products.

Further advantages of the wet-ash method are brought out in its simplicity, ease of manipulation, the number of samples that may be run simultaneously, quantity of sample required, and accuracy. If the determination of certain other organically combined constituents are desired, aliquots of the wet-ash solution may be used.

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THE MOISTURE RELATIONS OF TEXTILES

*A Survey of the Literature**

P. W. CARLENE

INTRODUCTION

THE sorption of water by textiles is of considerable interest to those engaged in their manufacture, processing and finishing. There are in constant use in the textile industries today many long-established processes that depend for their success on the modifying influence of water vapor on the physical characteristics of the materials, well-known examples being carding and spinning, the storage of tops prior to spinning, the release of latent strains in wool fabrics by "London Shrinking," the crepeing of fabrics, the schreinering of cotton, and general drying and conditioning of yarns and cloths of all kinds. The rapid developments in textile finishing that have taken place within recent years, however, and the special problems that have arisen in this and other fields owing to the introduction of newly discovered fibers, have stimulated the desire for a more comprehensive knowledge of the moisture relations of textiles, since it is obvious that such knowledge is of great importance in many investigations dealing not only with these new fibers, but also with new finishes and methods of processing that are being, or will be, applied to new and old materials alike. In this paper, therefore, the results of the more important investigations into the hygroscopicity of textiles have been collected and presented in a form that should prove of value at the present time to those concerned with the manifold aspects of modern textile processing.

Prior to 1924, when Urquhart and Williams[1] began their classic researches on the moisture absorption of cotton, the only fairly comprehensive work was due to Schloesing[2] and Hartshorne.[3] Both investigators, by plotting water sorbed against relative humidity, obtained the sigmoid type of curve characteristic of the absorption of vapors by many colloidal gels, but their results were not in good agreement, particularly at high humidities.

Absorption curves were also given by Trouton[4, 5], Masson and Richards[6], and Travers[7], whilst a summary of the humidity equilibria of many common substances, including textiles, was presented by Wilson and Fuwa[8]. The latter authors also gave curves illustrating the decrease in regain of textiles at constant humidity with rise of temperature.

In all these investigations a single curve was given as representing the relation between regain (defined as moisture sorbed expressed as a percentage of the dry weight of the textile) and relative humidity at any one temperature. Some indication that textiles, in common with other gels, exhibit hysteresis effects may be obtained from the work of Hartshorne,[3] and Masson and Richards[6], but it was Rakovski[9] who demonstrated the existence of a real hysteresis in cotton, flax and hemp. Further, Rakovski showed that if a material was removed from an atmosphere of greater humidity to one of less, the resulting equilibrium moisture content would be less than if it had been removed from a saturated atmosphere to the equili-

* A communication to the Society of Dyers and Colourists. Reprinted from their Journal, September, 1944.

brium atmosphere, but greater than if it had been introduced to that atmosphere in the dry condition. These results suggested that the absorption and desorption curves enclose an area, any point in which, under suitable conditions, may represent a state of equilibrium between the moisture regain of the material and the humidity of the atmosphere to which it is exposed. Such a view was confirmed later by the work of other investigators and its significance in textile testing emphasized.

Most of the work of outstanding importance on this subject has been done within the last twenty years, and the following survey is therefore concerned essentially with results that have been published within this period.

THE ABSORPTION AND DESORPTION OF WATER BY FIBERS

(a) Cotton—The most extensive investigations on the moisture relations of cotton have been made by Urquhart and his collaborators, who determined the absorption-desorption isotherms of raw and soda-boiled cotton and studied the effects of such factors as drying under different conditions, temperature, and mercerizing upon the absorptive capacity of the fiber. On the basis of their results, these workers put forward a theory for the absorption of water by cotton which accounted for the observed hysteresis effect.

Urquhart and Williams[1,10] demonstrated in preliminary experiments that the absorption-desorption isotherms of raw and purified cottons were sigmoid in shape and that a hysteresis effect did, in fact, exist. Typical curves for different textile materials are shown in Figs. 1 and 2. Thus, a sample of cotton which attains equilibrium regain by desorption has a higher regain than if it approaches equilibrium by absorption. In addition, drying at a high temperature reduces its absorptive capacity. Further, the removal of non-cellulosic impurities from cotton increases the hysteresis of the material. This increase is shown by the displacement of the absorption curve towards the vapor pressure axis, since purified cotton is less absorptive than the raw fiber under absorption conditions.

Their early experiments indicated that hysteresis did not extend to zero humidity, but that the absorption and desorption curves met at 1.8% R.H. Later work however, did not confirm this observation. On the other hand, there was no apparent tendency for the hysteresis loop to close at the saturation value, and further investigation demonstrated that there were considerable difficulties attending the determination of regains at or very close to 100% R.H.

The effect of temperature upon the absorption of water by soda-boiled cotton was also investigated. Previous workers[2,8,9] had observed that the regain of cotton at constant relative humidity decreased with rise in temperature. Urquhart and Williams[11] proved that up to 80% R.H. the regain of cotton at constant humidity decreased with rise in temperature over the whole range (10°-110°C.) investigated. Above 80% R.H., however, increase in temperature up to 50°C. caused a decrease of regain, whereas above 50°C. the regain began to *increase* with rise in temperature. This behavior was explained in terms of an increase in the accessible surface of cotton caused by the rise in temperature. As the temperature rises, more and more surface is exposed until, at about 50°-60°C., this effect more than compensates for the fall in the amount of water absorbed per unit area and the moisture regain of the material increases. Clearly, then, all those processes which depend for their success upon swelling will be facilitated by a rise in temperature and will become easier above 60°C. at high humidities.

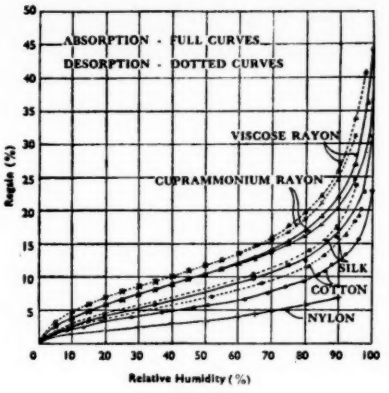

FIG. 1

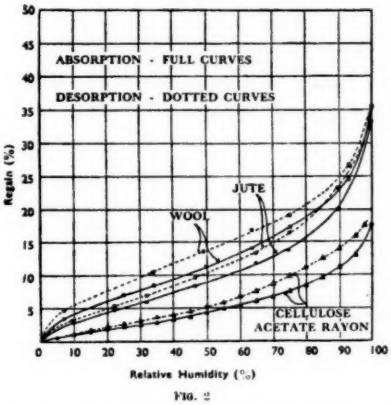

FIG. 2

Investigation of the absorptive capacities of several varieties of cotton, e.g., Sea Island, Sakel, and Texas[12], demonstrated that the differences observed among the raw cottons are considerably reduced by partial purification, e.g., by boiling with water, and it was concluded that the considerable differences exhibited by the raw cottons are due mainly to the presence of non-cellulosic impurities. The removal of such impurities is accompanied by a reduction in hygroscopicity that is greater in desorption than absorption.

In their earlier work Urquhart and Williams[10] attempted to explain the absorption of water by cotton in terms of a modification of Zsigmondy's theory of the absorption by inelastic gels. Later work by Collins[13] showed that cotton is an elastic gel which increases steadily in volume as it absorbs water, hence an alternative explanation for the mechanism of moisture absorption was advanced[14].

According to this theory, an elastic gel is considered to be composed of a mass of micelles, the state of aggregation of which depends upon the amount of imbibition. The hydroxyl groups in cotton are regarded as the points of attachment of the sorbed water molecules, a view supported by observations that esterification of cellulose hydroxyl groups reduces the absorptive capacity of the material[8,15].

Urquhart's theory is as follows—In a growing cotton hair, cellulose is formed in the presence of water which becomes attached to the hydroxyl groups. As the hair dries, these groups are freed and there is a tendency for rearrangement of the cellulose molecules to occur in order to satisfy the residual valencies of the hydroxyl groups and reduce the potential of the system. X-ray examination has indicated that the cellulose micelles are arranged in spiral formation and it seems probable, therefore, that in addition to molecular re-arrangement there may also be actual twisting of the micelles themselves, a factor which would explain the latent strain in dry hairs, removable by immersion in water. Thus, some molecules (or micelles) may be bound together more rigidly than others, with the result that even in the dry state there are many free active groups on the micellar surfaces.

If the cotton hair is now allowed to absorb water, the sorption takes place first at these active groups. As this water tends by its attraction to restore the original orientation of the surface, the number of active groups increases during absorption. Since, however, there is less tendency for a group to return to the surface than there was originally for it to leave it, the absorbing surface is in a less active condition during absorption than desorption, and hysteresis results.

The surfaces of the micelles in cotton hairs from the boll are regarded as being in an exceptionally active state initially, but many of the active groups are considered to be permanently caught into the body of the micelles when such material is dried. Precise measurements showed that the primary desorption curve ob-

tained by drying cotton taken directly from the boll could not be reproduced; hence initial drying of hair from the boll permanently impairs its hygroscopicity. After the first drying, however, absorption and desorption curves are perfectly reproducible.

Drying at an elevated temperature decreases the number of available active groups, since the molecular vibration is then greater, hence absorbency would be expected to fall. If, however, exposure to heat occurs in the presence of excess of water, the increased energy of vibration should result in an increase in the number of available groups, since each group as it momentarily frees itself should have its residual valency satisfied by the attraction of an absorbed water molecule. Such treatment, therefore, should lead to an *increased* absorptive capacity. Both these deductions were confirmed experimentally.

Since there is a limit to the number of available active groups, hysteresis would be expected to decrease with increasing temperature, probably even to vanishing point when the limiting value of available groups is attained. Desorption experiments proved that hysteresis at 40°C. was considerably less than at 25°C., whilst, at a regain of 12%, hysteresis disappeared altogether at 100°C.

A further study of hysteresis[16] made it clear that the absorption and desorption curves are merely the boundaries of an equilibrium area, any point in which may be capable of representing the regain of a sample of cotton under suitable conditions of humidity and pre-history. Hysteresis cycles which do not extend to zero or saturation lie within this equilibrium area, and transitions from one boundary curve to another take place by long curves similar in shape to the boundary curves themselves. Hence, in conditioning samples for physical testing, they should be exposed to an atmosphere of humidity as far removed from the test humidity as possible before conditioning at that test humidity. It is preferable that a lower humidity should be chosen, since by so doing the variability at high humidity is avoided and the final regain will lie on the boundary absorption curve of the material.

Referring to the apparent lack of definition of the hysteresis loop at saturation, a closer investigation[16] revealed that below 80% R.H. all desorption curves coincide, but that above this value the amount of water retained is greater, the greater the original excess above the saturation value, so that the upper limit (about 40% regain) was derived by removing water from thoroughly wet cotton. This value of 40% for saturation regain of cotton should be compared with that of 50% obtained by Coward and Spencer[17] by centrifuging wet cotton in a saturated atmosphere.

Urquhart suggested that the failure of the absorption and desorption curves to meet at high humidity is due to the fact that water in excess of saturation fills the spaces between hairs and their subsequent emptying causes a small reduction in pressure owing to the curvature of the water spaces in them while the total amount of water present exceeds the saturation value. Although Urquhart admitted that this theory was not without its difficulties, he considered it likely that the variability of the hygroscopicity of the material at high humidities is a property of its state of aggregation.

Peirce[18], in a review of the position, thought it possible to divide the effects of absorbed water into two classes, viz. *(a)* that in which water influences the physical properties (strength, elasticity, rigidity, swelling and evolution of heat), and *(b)* that in which it provides the necessary moisture for chemical reactions and maintains a vapor pressure. Thus, one portion of the absorption is connected intimately with the molecular structure of the cellulose (1 mol. water per hexose unit) and produces effects of class *(a)*, while the remaining water is held more loosely and fills the spaces available under attractive forces like those in a liquid, thus accounting for the effects of class *(b)*. By a mathematical treatment of the theory, calculated isotherms were obtained which agreed satisfactorily with the observed curves, and from them a constant was derived giving a measure of the openness of structure and of swelling. The values of this constant taken in relation to the fine structure of cotton cellulose presented a picture of the hair as composed of very fine spirals. Absorption, swelling, mercerization or esterification open up the spaces and weaken the cohesion between these elements without affecting their external structure or strength.

More recently, Walker[19] proposed an alternative explanation in terms of different internal surfaces available for absorption. The cotton fiber was represented as consisting of growth rings which are composed of parallel fibrils running in spiral form from end to end of the hair. These fibrils are laid down one on top of the other in successive growth rings, so that pits are formed between the piles of fibrils and each fibril is separated from its neighbor by an air space. Less than half the internal surface, termed fibril surface, is thought to be involved in that moisture absorption which causes transverse swelling of the cotton hair. Upon this surface, multimolecular layers of water are assumed to condense, thus forming long chains of water molecules, the points of attachment of which are hydroxyl groups on the cellulose surface. The remaining internal surface, which appears responsible for the small longitudinal swelling of cotton, is located on the ends of the crystallites, on which only a monomolecular layer is assumed to form.

The differentiation between fibril and other internal surface is believed by Walker to offer a more definite explanation of the two-phase absorption of water vapor as proposed by Peirce, in that the *(a)* phase is concerned with adding water to specific points on the hexose units where such surface is readily available for absorption, and the *(b)* phase is also concerned with a definite number of active groups within the body of the fibrils, but much less accessible than those in the fibril surface.

The work of Tankard[20], who studied the ternary system cellulose-water-sodium thiosulfate, suggested that for each type of cellulose examined there was a maximum amount of water which could be regarded as having entered into chemical combination. Thus, the maximum value for bleached cotton and linen cellulose was 0.5 mol. water per hexose unit, and 0.75 mol. for mercerized cotton cellulose if dried subsequent to mercerization. A value of 1.0 mol. was obtained for mercerized cotton cellulose which had not been dried after mercerization, for mercerized linen cellulose whether dried or not after mercerization and for viscose rayon. In the case of cellulose triacetate, the results indicated a value of 3.0 mol. per hexose unit.

Babbitt[21] collected the data on the absorption of water by cellulose to obtain a unified picture of the phenomenon. The Langmuir equation is shown to fit the absorption isotherms up to 20% R.H. Between 20% and 80% R.H. the shape of the isotherm can be explained either in terms of polymolecular absorption or in terms of a unimolecular absorption theory which assumes a decrease in the attraction of the absorbent with increase of the number of absorbed molecules. The heats of absorption of cellulose (wood and cotton) taken from various sources yield fairly consistent values and indicate that the absorption of water by these materials differs only in the area of absorbent surface.

Babbitt concluded from his studies of the thermodynamics of water absorption that the water molecules are attached by two hydrogen bonds connecting the oxygen atom in the water molecule to two of the oxygen atoms in the cellulose side-chains. He felt that this conception explained the greater penetrative power of water over other small molecules and was in agreement with the current view concerning the ability of water to alter the

physical dimensions of cellulose without affecting the crystal dimensions.

The most recent study of the water absorption of cotton cellulose has been made by Assaf, Haas and Purves[54], who have put forward a new interpretation of the cellulose-water isotherm.

By means of the thallous ethylate method, they determined on highly swollen samples of cotton the respective percentages of cellulose theoretically accessible to water vapor and nitrogen gas, and also measured their moisture absorption. The moisture content at the second point of inflexion in the sigmoid isotherms (at about 50% R.H.) was approximately that predicted from the results of the thallous ethylate measurements, assuming the association of one water molecule with one accessible alcoholic group. This region in the isotherm was considered to be equivalent to a unimolecular water layer. At the first inflexion in the isotherm (occurring at 7-10% R.H.), the moisture content was about one-third that at the second inflexion, which led these workers to suggest that the high affinity of cellulose for water in this region [the powerful *(a)* absorption assumed by Peirce] was mainly a function of the strong hydrogen-bonding capacity of accessible primary alcoholic groups. The intermediate portion of the isotherm represented the water less strongly hydrogen-bonded to the secondary alcoholic groups, although its shape was influenced at the higher humidities by swelling and capillary condensation effects.

(b) Rayons—Work by Urquhart and Eckersall[21] demonstrated that the absorption-desorption isotherms of the regenerated celluloses have the same form as those for cotton, but that the actual values for the regain at any particular humidity are all appreciably higher, the highest hygroscopicity being shown by cellulose nitrate rayon. The rayons exhibit the phenomenon of hysteresis and the absorption-desorption curves enclose an equilibrium area, as in the case of cotton. Cellulose acetate rayons differ from the regenerated cellulose type in that their isotherms do not exhibit the rapid rise at low humidity, an effect obviously related to the esterification of the hydroxyl groups.

Similar work by Sheppard and Newsome[15] confirmed that esterification by nitration or acetylation reduced the hygroscopicity of cellulose. Two types of esters can be formed *(a)* by fibrous esterification and *(b)* by solution esterification. Series *(a)* esters were found to exhibit the fine structure of the normal cellulose lattice system, whereas series *(b)* esters gave a hydrate type of fine structure on de-esterification and showed a higher regain than esters of type *(a)*, a fact which could be accounted for by intramicellar water absorption. Complete acetylation to the triacetate did not reduce the regain as much as might have been expected, hence a considerable portion of the total regain of cellulose and its esters must be due to intermicellar absorption.

The hysteresis loops for cotton and rayon yarns show no tendency to close at saturation, an observation which was explained in terms of the filling with water of the small capillary spaces between the fibers. Sheet viscose, however, does not possess such a system of capillary spaces and it would be expected, therefore, that its hysteresis loop would close at saturation. Figures obtained by various workers[21,22] indicate that this is so. Simril and Sherman Smith[22] also found that an increase in temperature caused a reduction in the absorptive capacity of Cellophane and a narrowing of the hysteresis loop. On the basis of their results these authors explained the hysteresis effect by an extension of Urquhart's theory.

(c) Wool—According to Speakman[20], the absorption-desorption isotherms of different varieties of wool show that their absorptive capacities are very similar and that differences between varieties appear to be related to their relative fineness. A marked hysteresis was observed in all cases. Again, the absorption and desorption curves merely enclose an equilibrium area, and transitions are made from one curve to the other by intermediate sorption curves in the manner observed for cotton.[24] The range of humidity over which wool must be conditioned to pass from the boundary absorption to the boundary desorption curve is independent of regain and is about 18%.

Speakman and Stott[25] observed that wool dried from regains lower than saturation becomes less absorptive as the temperature of drying increases. Partial as well as complete drying causes this effect, but drying from saturation, or heating wool dried at a low temperature, has no such influence. The normal affinity of wool for water may be restored by allowing it to reach saturation with water vapor, but the reduced affinity of wool heated over water at a high temperature is irreversible. Although the general effect of heating wool with water at high temperatures is to reduce its absorptive capacity, the unaltered affinity of wool dried from saturation was explained by the hypothesis advanced by Urquhart to account for the similar behavior of cotton.

Absorption isotherms of chosen wools determined at intervals of 5°C. from 25°C. to 55°C. revealed that the amount of water absorbed at low partial pressures decreased as a linear function of temperature[26]. When the partial pressure is 0.975, however, the isobar shows a minimum at 43°C., thus confirming the view that the swelling of wool is at a minimum at about 40°C. Complete isotherms for temperatures above 55°C. could not be obtained because of disulfide bond attack.

Similar work by Goodings[27] gave results which agreed with those of previous workers, except in the shape of the curves at high humidities. The indications were that at saturation the regain for wool is much higher than the generally accepted value of 33%.

Shorter[28], from general thermodynamical reasoning, obtained an expression for the heat of absorption of water by textiles which is a form of the Kirchoff equation for the heat of dilution of a solid. Hedges[29] tested these conclusions and found that the heats of absorption given by a form of Kirchoff equation and those deduced from the heats of wetting were in fair agreement. The process of water absorption by wool was considered by Hedges to fall into three stages with no sharp line of demarcation between them. First, water entering the wool (up to 5% regain) is absorbed at the large surface presented by the capillary structures and is accompanied by a large heat of absorption. During the second stage of the absorption, i.e., when the true absorption is complete, there is a filling up of the pores (5-25% regain). The third stage (25-33% regain) is an osmotic absorption and the heat of absorption becomes very small as saturation is approached.

King[30] observed that stretching caused wool fibers to increase in weight, and explained this as being due to a distortion of the pores which decreased their diameter, thus increasing the tendency of the absorbed water films on the pore walls to coalesce, with consequent filling of the capillaries. Permanently set fibers, however, showed a loss in weight which was thought to be due to a sealing up of the pores, thus reducing the water-holding capacity.

From a study of the treatment of wool with *(a)* formaldehyde and *(b)* nitrous acid, which react with the amino-groups of wool, Speakman[20] concluded that these groups play a relatively insignificant part in water absorption by untreated wool, since wool treated in this manner was only slightly less hygroscopic than the corresponding untreated material.

Measurements of fiber rigidity[31] confirmed Hedges' earlier view that the sorption of water by wool comprises three stages. The first amounts of moisture taken up have little influence on rigidity, but are accompanied by large evolution of heat, and this water is probably absorbed within the micelles without seriously distorting the crystal structure. Subsequent absorption causes a linear fall in rigidity, whilst the last portion up to saturation again causes no change in rigidity, whilst the last portion up to sat-

uration again causes no change in rigidity and occurs with little evolution of heat. This water is considered to flood the gross pores of the fiber.

Recently, Speakman[53] has made a detailed analysis of the absorption isotherm of wool by applying the method of Peirce[18] to split up the absorbed water into α- and β-phases. In contradistinction to cotton, α-water appears to be without effect upon the rigidity of wool, but up to 80% R.H. there is a linear relationship between the relative rigidity of wool fibers and the amount of absorbed β-water. Deviation from this relationship at high humidities has led Speakman to suggest that β-water is of two types, viz., one which modifies rigidity and a second which is without effect on rigidity, but is most probably capillary condensed water. The β-water responsible for the change in rigidity is considered to react with wool in such a way that 1 mol. is associated with each peptide group at saturation. Thus, the hydrogen bonds between neighboring peptide groups, on which the cohesion and configuration of the keratin complex so largely depend, are replaced by similar bonds between peptide groups and water molecules with consequent reduction in the rigidity of the fibers. On the other hand, α-water, which is absorbed with great evolution of heat and little change in rigidity, is believed to be associated with the hydrophilic side-chains of wool, in support of which it is shown that the heat of wetting of wool with α-water is of the same order as the heat of hydration of hydroxyl groups and of carboxyl ions.

Cassie[32] studied the variation of regain of wool with changes in humidity and temperature, and showed that the slow rate of change in regain during conditioning is due less to the slow sorption of water vapor by the fibers than to the diffusion of water vapor through the layers of air surrounding the fibers and to the difficulty experienced by fibers in losing or gaining heat generated or absorbed when the regain increases or decreases. The importance of these findings is discussed in Cassie's paper in relation to the time of conditioning and their application to hygiene of clothing.

(d) Silk—The moisture relationships of silk were investigated by Schloesing[2], and by Oguri[35], but without reference to the existence of a possible hysteresis effect. Complete absorption and desorption curves for degummed silk, which demonstrated clearly the hysteresis effect, were obtained by Goodings and Turl[34]. The curves were sigmoid in shape, so that the behavior of silk is analogous to that of wool and cotton. A saturation value of 35.8% regain was deduced from density and swelling data. The density of silk increased gradually with decreasing regain up to a maximum at about 3-5% regain, after which a slight fall occurred, and this led Goodings and Turl to conclude that some differentiation may be made between the first few per cent of water vapor absorbed and that subsequently taken up at higher humidities.

(e) Jute—The earliest results for the moisture relations of jute were obtained by Pfuhl[35] in 1888, from whose data the present International Standard Regain for jute was adopted. A regain curve for jute obtained by Storch was also quoted by Wilson and Fuwa[5]. Only one isotherm was given by these early workers, but Ingmanson and Vacca[36] proved that jute, in common with other natural textile fibers, exhibits a hysteresis effect, the absorption and desorption curves being of the anticipated sigmoid form. The absorption of the first few per cent of water is accompanied by a considerable evolution of heat, whilst at the other end of the scale, as saturation is approached, the affinity for water becomes less and the heat evolved is very small.

Recently, Powrie and Speakman[37] investigated the absorption of water by different qualities of jute at 25°C. and confirmed the presence of a considerable hysteresis between absorption and desorption. The absorptive capacity of jute varies with the quality, but in general there appears to be a relationship between the affinity for water and the xylan + lignin content of the sample.

The regain curves for jute treated with waterproofing materials, e.g., asphalt and bitumen mixtures, were interesting[38] in that no change in the shape of the curves or in the extent of the hysteresis was caused by the applied finish. The rate of attainment of equilibrium regain, however, was considerably retarded.

(f) Nylon—Figures which have been published within recent years[28,29] for the regain of nylon at different humidities show that the absorption curve is sigmoid in shape. The hygroscopicity of nylon is very low compared with that of the natural textile fibers; thus at 65% R.H. nylon absorbs only 4.2% of water, whereas wool takes up 14.0-19.0% depending upon its form, silk 11.0% and cotton 8.5%. Nylon, in fact, resembles cellulose acetate (regain 6.0%) in low water absorbency. Again, when nylon is thoroughly wetted and hydroextracted only 20-25% of moisture is retained, whereas under identical conditions cotton retains 50%[39]. It should also be noted that, in the light of the available data, there is no evidence to suggest that nylon exhibits a hysteresis effect. The low absorbency of this fiber is responsible in part for the special difficulties experienced in its dyeing and finishing.

To conclude this part of the survey, Table I is appended. Table I gives the standard regains (at 65% R.H. and 22°C.) proposed by the Textile Institute[40] for the textile industry, as well as the saturation regains where these figures are available.

TABLE I

Material	*Standard Regain (%)*	*Saturation Regain (%)*
Cotton	8.5	about 40.0[17]
Silk	11.0	35.8[56]
Flax and Hemp	12.0	—
Jute	13.75	about 33.0[35]
Wool	16.0	34.0[53]
Wool (tops combed with oil)	19.0	—
Wool (tops combed without oil)	18.25	—
Worsted yarns	18.25	—
Carded woolen yarns	17.0	—
Wool noils (ordinary)	14.0	—
Wool noils (scoured and carbonized)	16.0	—
Woolen and worsted cloths	16.0	—
Viscose rayon	11.0	about 45.0[22]
Cuprammonium rayon	11.0	31.0-36-0[22]
Cellulose acetate rayon	6.0	17.0-19-0[22]
Nylon	4.2	about 10.0*

* Estimated value.

Howlett, Morley and Urquhart[41] have recorded figures for the regains (determined at 65 per cent R.H. and 25° C.) of various textile fibers, including some of the newer fibers, as follows—

	% Regain
Casein fiber	13.0
Celanese FS rayon	9.0
Cotopa	3.0
Polystyrene	0.0
Vinyon	0.0
Rayolanda X	10.0

THE INFLUENCE OF MOISTURE ON THE PHYSICAL CHARACTERISTICS OF TEXTILE FIBERS

(a) Elastic Properties—Mann[42] observed that the breaking load of cotton hairs in general increased with increasing humidity and that the rate of loading did not seem to play an important part in the effect. This relationship between breaking load and humidity was not linear, for the curve flattened out above 66 per cent R.H., but did not show any conclusive evidence of a maximum in the neighborhood of 80 per cent R.H. as claimed by Wilkomm.[43] These observations were later confirmed by Brown, Mann and Peirce.[44] The extension at break of cotton hairs is influenced by humidity in the same way as that of yarns, and gradually increases with increase in humidity, although the rate of increase becomes less towards saturation. In fact, the extensional behavior of cotton hairs so closely parallels that of yarns that it appears that the elastic behavior of single hairs has a more dominant influence than is usually recognized.

Although the slope and length of the load/extension curves of cotton hairs at one humidity were found to vary for individual hairs, the shape of these curves was fairly constant. Attention was drawn to a characteristic feature, viz. their con-

vexity with respect to the load axis, in contradistinction to the concavity of form usually observed for an imperfectly elastic body, e.g. viscose rayon. Further, beyond a load of 3 to 4 g. the slope of the load/extension curves was almost uniform, irrespective of temperature and humidity, which led Brown, Mann and Peirce to assume that the end of this slope represented the true extension of the structural elements of the fiber, any further extension (3 per cent at saturation and practically negligible at 0 per cent R.H.) being that of the spirals in the cotton hair. Soda-boiled cotton extended more than the raw material, and mercerized cotton had a greatly increased extension which corresponded to the opening up of its internal structure.

Speakman's investigations of the elastic properties of wool fibers led him to determine the work required to stretch them 30 per cent of their original length at different humidities.[42] The energy required decreased with increasing humidity and the energy/humidity curve was slightly, although definitely, sigmoid in form. Comparison of this curve with the absorption isotherm for wool afforded additional evidence that absorption occurs at high humidities mainly by capillary space flooding.

Dry wool fibers cannot be extended much further than 30 per cent before rupture, but increasing the humidity increases their extensibility. The general form of the load/extension curves does not alter appreciably with changing humidity, but the Hooke's law region and region of rapid extension decrease in slope with fall in humidity. Transition from the region of rapid extension to the third region (slow extension) occurs at approximately the same extension in all cases, while the point of deviation from Hooke's law takes place uniformly at one extension, viz. 2 per cent.

Denham and Lonsdale[45] explored the relationship between relative humidity and the tensile properties of silk. With rise of humidity, the breaking load decreased, whereas extension at break increased, although extension at the proportional limit decreased steadily from dryness to saturation. With silk yarns[47] the breaking strengths were not affected significantly by a variation in humidity from 33 per cent to 55 per cent, but above 55 per cent R.H. the yarn became weaker. Extension at break increased as the humidity rose.

(b) Swelling—Collins[13] found that when the swelling of cotton hairs is plotted against relative humidity, a hysteresis effect is revealed, the swelling being greater under desorption than under absorption conditions. The curves are sigmoid in form. Lateral swelling is much greater than longitudinal swelling at the same relative humidity, e.g., in water the longitudinal swelling is 1.12 per cent, as against 20 per cent for the change in diameter (all data are based on the dimensions of the absolutely dry fiber). Swelling in water is at a minimum at about 45° C.

Speakman[23] observed that the increase in length of wool fibers in water is 1.19 per cent and that of the diameter 17.5 per cent, corresponding to an increase in cross-sectional area of 38 per cent. As X-ray data have shown that the dimensions of the unit cell remain unchanged when the wool fiber is immersed in water, the lateral swelling must be due to separation of the micelles.

The lateral swelling of different varieties of silk increases gradually with increasing humidity.[48] Japanese silk at 100 per cent R.H. showed a swelling of 18.7 per cent (increase of diameter), whereas Italian silk gave a figure of 16.3 per cent. The figures for the former variety indicated the existence of a hysteresis effect in swelling. These observations were confirmed recently by Goodings and Turl[21] who determined volume swelling from regain and density measurements. From the volume swelling and longitudinal swelling, lateral swelling was calculated, the results being in excellent agreement with those of previous workers.

According to the work of Lawrie,[26] who measured the swelling of various rayons with water, the increase in diameter of viscose rayon is 35.0 per cent, Celta 25 per cent, and cuprammonium rayon 41-53 per cent, depending on the variety, while cellulose acetate rayon varies from 9-14 per cent. Cellulose triacetate exhibits the lowest swelling, viz. 2-3 per cent.

(c) Rigidity—Peirce[39] examined the effect of humidity on the rigidity of cotton hairs. The curves relating this property to humidity were S-shaped and very similar to the moisture isotherms for cotton. Saturation rigidity was less than one-sixth of that in the dry state and decrease in rigidity with rise of humidity was rapid in the first and last 10 per cent regions, while the middle portion showed an approximately regular decrease. When the logarithm of the rigidity was plotted against regain, the points were found to lie on a straight line which could be expressed in terms of a simple exponential formula. The slope of this line showed that the rigidity was halved by the addition of 10 per cent moisture. An increase of temperature at constant regain decreased the rigidity to the extent of about 0.25 per cent for 1° C. in dry cotton, increasing to about 0.6 per cent at 7 per cent regain. Around 60 per cent R.H. the effect of 10° C. change of temperature at constant humidity was about the same as a change of 5 per cent R.H. at constant temperature. In saturated air the rigidity appeared to increase with change of temperature above or below 20° C.

The first amounts of water absorbed by dry wool cause little change in the rigidity.[23] Subsequent absorption of water results in a linear fall in rigidity up to 22 per cent regain, after which the change observed is again small. These results suggested to Speakman that absorption of water occurs on particular groups in the keratin structure.[53] One other interesting feature was noted, viz. that the rigidity is not dependent solely on the relative humidity, but is also governed by the direction in which that humidity is approached.

EFFECT OF PROCESSING UPON THE MOISTURE ABSORBENCY OF TEXTILES

Mention has been made of the effect of drying conditions upon the absorbency of textiles, and that the employment of high temperatures in general decreases their hygroscopicity. Further investigations[50] have indicated the limits of moisture content which may be expected in the fibers examined when the atmosphere in contact with them is maintained at any desired temperature and humidity. When the data were plotted in terms of logarithms of the moisture content at any fixed humidity against the reciprocal of the absolute temperature, straight line relationships were obtained showing changes of slope between 93° C. and 104° C.

When samples of yarns made from different fibers, e.g. cotton, wool, rayons and silk, were wetted out and exposed to temperatures of 105°-150° C. at humidities ranging from 1-95 per cent, it was found that heating for 6 hrs. at 105° C. over the range of humidity examined weakened all of them. The breaking strength and elongation at break of viscose and cuprammonium rayons and of silk and cotton decreased still more at higher temperatures. Heating at the higher humidities resulted in lower breaking strength and elongation at break for all except the raw cotton yarns. The standard fluidity values for all the materials (except wool) were also increased under these conditions, while the affinity of the cellulosic fibers for certain dyes was decreased and that of wool increased. Little effect was observed when the yarns were heated for only 30 min. at 150° C., except with the viscose and cuprammonium rayons which were adversely affected, but prolonging the heating at a given temperature and humidity was accompanied by increased damage.

Urquhart and Williams,[51] in an examination of the relationship between the degree of mercerization of a cotton and

(Concluded on Page 334)

The Serviceability of

CURTAIN MARQUISETTES

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ABSTRACT

Fourteen unfinished all-cotton plain curtain marquisettes (Group I), 13 finished, all-cotton, plain marquisettes (Group II), and 6 finished, plain marquisettes containing rayon (Group III) were purchased directly from manufacturers or their selling agents and comprise a representative cross section of this type of fabric.

Curtains were made from these materials by sewing together four lengths of fabric for each curtain, each length from a different cloth. The test curtains were hung at east windows and were laundered every 2 months. The various fabrics were tested when new and at the end of 4, 8, and 12 months of service.

The average warp breaking strength of the new fabrics in Group I was 24.9 pounds, of those in Group II, 26.0; and in Group III, 20.9 pounds. The corresponding filling values were 10.6, 11.4, and 12.7 pounds. With service, the breaking strength in both directions decreased, the loss in the warp exceeding that in the filling in spite of a gain in the number of warp yarns to the inch due to shrinkage. The percentage loss in breaking strength for the group of unfinished cottons after six washes was less than for the finished cotton materials, in both test directions. On the whole, the rate of loss in breaking strength was greater during the first months of service than during the latter part of the study.

The peak in warp yarn count for the majority of fabrics in all three groups and in the filling count for the materials in Groups I and III was reached with the fourth laundering. The maximum filling count for 10 of the 13 finished cotton marquisettes occurred with the second laundering.

For new materials in Group I, the mean weight was 1.3 ounces per square yard; for Group II, 1.1; and for Group III, 1.2 ounces. The highest weight per square yard for all but 7 of the 33 fabrics tested was recorded after the fourth laundering. From then on, the effect of wear offset the gain in weight caused by shrinkage.

The average fluidity of the unfinished cotton marquisettes was less than that of the finished which in turn was less than that of the rayon fabrics. With service, the fluidity values for all materials increased but this increase was less for the unbleached marquisettes than for the bleached. Generally, the gain in fluidity was greater during the first months of service than during the latter part of the study.

For the most part, shrinkage in width exceeded that in length for the all-cotton materials, whereas, the reverse was true in marquisettes containing rayon.

The unfinished cotton fabrics had a higher nonfibrous content than the finished cotton materials. Two marquisettes containing rayon had a relatively high percentage of extraneous substance, one exceeding any value reported for the unfinished fabrics.

DURING recent prewar years the production of combed and part-combed marquisettes increased until in 1939, the last year for which manufacturing figures are available, 311,700,744 square yards were produced *(12)*. Of this total nearly one-fifth was without decoration. Some of this plain marquisette was probably used for various clothing purposes but no doubt a large proportion went into glass curtains—ruffled or tailored.

In spite of the enormous quantity of this fabric sold, either as ready-made curtains or by the yard, virtually no data concerning its performance in service are available. Although some work has been done on the effect of sunlight and atmospheric conditions upon cotton fabrics, few investigators have used glass curtain materials as the test fabric. Therefore, the combined laboratory and serviceability study on curtain marquisettes reported herein, provides information useful to manufacturers and consumers alike.

Cunliffe and Farrow *(5)* determined that fine cotton yarns deteriorated more upon exposure to light than did coarse yarns, and that bleached cloth was more rapidly tendered by light than unbleached. They concluded that fabrics likely to be subjected to bright sunlight for long periods should be made from as coarse and hard twisted yarns as is consistent with other properties demanded of the cloth. Grimes *(6)* reported that resistance of fabrics to tendering by sunlight was almost directly proportional to their thickness, the thick ones having greater resistance than the thin. Simola *(10)* found that cotton yarns exposed to sunlight through a double glass window for 5 summer months lost 17.8 per cent of the original strength. Fumes from soft coal produced noticeable tendering in cotton fabric according to Conn *(3)*. Time of exposure had a greater effect upon tendering than did temperature and/or humidity. Bayley *(2)* stated that heat from radiators and mechanical wear against screens and window sashes, as well as sunlight deteriorate curtain materials.

[1] Appreciation is expressed to Ruth Elmquist Rogers for preparation of the section on fluidity measurements and to Lillian Weidenhammer for determinations of nonfibrous materials.

EXPERIMENTAL PROCEDURE

Materials Studied

Thirty-three plain curtain marquisettes were included in this study. Fabrics with clip dots and embroidered or printed designs were omitted because of the variability in the amount of design and the analytical difficulties that arise from the presence of decoration. The materials, bought prior to the war directly from manufacturers or from their selling agents, comprised a representative cross section of this type of fabric generally available to the consumer. In color, they ranged from white to deep tan.

Fourteen of the 33 materials were all-cotton and unfinished. The remaining 19 were finished ready for the retail market. Thirteen of this latter group were all-cotton, 3 had a cotton warp and rayon filling, and 3 were all-viscose rayon. It was impossible, however, to pair the unfinished with the finished fabrics since few manufacturers finished their own goods. To facilitate comparisons of the various fabrics, the 14 unfinished all-cotton marquisettes (numbered U_1 through U_{14}) were designated as Group I. Thirteen of the finished materials (fabrics F_1 through F_{13}) made up Group II. The remaining 6 fully finished fabrics (numbered F_{11} through F_{19}) containing rayon, comprised Group III.

Single yarns had been used for both the warp and filling in the cotton marquisettes and in the warp of the three cotton-rayon materials. One mixed fabric had a spun rayon filling; all other rayon yarns were multifilament.

Service Test

Curtains for the serviceability study were made by sewing together four 24-inch lengths of the marquisettes, each from a different fabric. Whenever possible, materials similar in weight, color, and fiber content were combined. Care was taken also to have pieces from the same fabric at different positions in the test curtains. That is, if the first length from a material was at the top in one curtain the second piece was put next to the top whenever the fabric was used again, and so on until a length from each material had been used in all four positions—the top, next to the top, next to the bottom, and the bottom. This plan was devised to offset any possible differences between the upper and lower parts of the curtain, due to wear and exposure to light. A strip of cheesecloth was sewed to the top, for the casing and to drop the test fabric below the window frame.

The test curtains were hung at east windows, each having a wide center section and two narrow side sections. In order to equalize wear and the effect of light, the position of the curtains at each window was shifted each month, curtains originally placed at the side being interchanged with those at the center section. After each 2 months of service the curtains were taken down, laundered[2], and rehung.

Laboratory Tests

Breaking strength (both strip and grab method), number of yarns per inch, weight per square yard, yarn number and twist (turns per inch), shrinkage, amount of nonfibrous material, and fluidity in cuprammonium hydroxide were determined for each of the materials when new. At 4-month intervals during service, curtains were withdrawn and tested to ascertain what changes had occurred in breaking strength, count, weight, and fluidity in cuprammonium hydroxide. At each period duplicate lengths of all the finished fabrics and one length of the unfinished fabric were tested.

Tests to determine the breaking strength, weight per square yard, yarn number, and amount of twist in the yarn were made in a laboratory maintained at 70°F. and 65 per cent humidity. All samples were conditioned for at least 4 hours before testing.

[2] All curtains were washed by the same procedure in the Bureau's service laboratory. Four curtains were put in a net laundry bag. Three bags constituted a washing load, in a suction type, electric washing machine. The first washing was a clear water break-down. This was followed by three washes, containing 400 ml., 200 ml., and 100 ml., soap gel (prepared by dissolving 125 gm. of neutral soap in 1 liter of water) respectively. Six rinses in clear water completed the washing. The temperature of each wash and rinse water was 30° C. The machine was operated for 5 minutes, emptied, and the curtains centrifuged for 1 minute before being put in the next water. Following the last rinse the curtains were dried on stretchers, under just enough tension to keep them straight and smooth. They were never starched or ironed.

The number of yarns in an inch of cloth was counted on the warp and filling breaking strength strips after they were pulled down to 1 inch.

All the strip and grab breaking strength tests were made with a motor-driven, constant specimen-rate-of-load type of testing machine with a maximum capacity of 50 pounds *(1)*.

The yarn number was determined on yarns removed from the fabrics according to the method described by Morrison and Hays *(8)*, and reported as the number of thousand yards to the pound (typp).

Since the marquisettes were too light to be weighed on the torsion balance especially designed to read in ounces per square yard, 2-inch squares of cloth were weighed on an analytical balance. The weights were then converted to ounces per square yard.

A modified standard method described by White and Hays *(13)* was used to find the amount of shrinkage.

The amount of nonfibrous substance (sizing) was calculated from the procedure published by the American Society for Testing Materials *(1)*.

The fluidities of 0.5 per cent dispersions of cotton and 2.0 per cent dispersions of rayon were measured at 20°C. in 25 ml. buret consistometers of the type described by Herschel and Bulkley *(7)*. The preparation, storage, and delivery of the cuprammonium solution were in accord with the recommendations of the American Society for Testing Materials *(1)*. The procedure employed for determining the fluidity was essentially the same as described by this Society with the modification that the time of flow was obtained for ml. portions of cuprammonium cellulose suspensions. Fluidity was calculated as described by the Society and in addition an adjustment for velocity gradient *(4)* was made.

RESULTS

The physical and chemical properties of the fabrics within each group differed widely when new and during service, even though the respective groups were similar in fiber content, finish, and appearance. (Tables 1 and 2).

Breaking Strength

In the new materials, values for warp breaking strength by the strip method averaged 24.9 pounds, 26.0 pounds, and 20.9 pounds for Groups I, II, and III, respectively. The corresponding averages for the filling breaking strength were 10.6 pounds, 11.4 pounds, and 12.7 pounds. In the majority of fabrics, the variation in breaking strength was less in the lengthwise direction than in the filling. This was true for both the raveled strip and grab methods (Table 1). The larger coefficient of variation for the breaking strength by the raveled strip method than for the grab, reflected the larger number of samples broken by the strip method which, in turn, gave a better representation of the fabric than was obtained by the few samples tested by the grab method.

The breaking strength of marquisettes in service during summer months, May through August, was considerably lower after two washes than when new (Tables 1 and 2). The average loss in warp strength for each group as a whole was 16, 19, and 24 per cent for Groups I, II, and III, respectively. The corresponding losses in filling strength were 15, 18, and 18 per cent. The greatest warp loss after two washes occurred in fabrics F_{12} and F_{18} where the warp strength was 33 per cent below that of the new material. The highest losses in filling strength at this test period were in fabrics F_{1}, F_{10}, and F_{18} where the decrease was 29, 40, and 39 per cent, respectively.

Most of the all-cotton fabrics used from September through April and tested after four washings showed a further decrease in breaking strength; however, the loss that occurred in this time was not substantially greater than that for the 4 summer months. In some instances, it was less. The all-rayon materials showed a smaller loss in strength in both directions after 8 months' use during the winter than after 4 months' wear in summer. This difference was probably due to the fact that there is less intense sunlight from September to April than from May through August, and that, since windows are kept closed more in cold weather, exposure is less direct than in summer.

When the curtains were withdrawn and tested after a year's service (May through April) all marquisettes showed greater percentage losses in both warp and filling strength than at previous test periods. After six washes, fabrics in Groups I and II had lost from about a fourth to a little less than half of their original strength both warpwise and fillingwise. The loss in strength in both directions for Group II fabrics was approximately the same as for those in Group I. In Group III, the losses in warp and filling strength for the three all-rayon fabrics (F_{17}, F_{18}, and F_{19}) were substantially lower than for the part-rayon materials. They were, however, about the same as the smallest losses that occurred in the two groups of cotton marquisettes.

When the study was concluded, 10 of the 14 unfinished marquisettes still had a warp breaking strength of 15 pounds or over and in 7 of the 10 fabrics the filling strength still exceeded 7 pounds. In each case, these values represented roughly two-thirds to three-fourths of the original strength. The percentage loss in strength

TABLE 1—Properties of 33 plain curtain marquisettes, when new

Fabric group and number	Yarns per inch[1]		Breaking Strength: Raveled strip method[1]		Breaking Strength: Grab method[2]		Coefficient of variability: Raveled strip method		Coefficient of variability: Grab method		Breaking strength index[3]				Weight per square yard[4]	Yarn number		Twist[5]		Shrinkage[6]		Non-fibrous content[7]	Fluidity[8]
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Raveled strip method: Warp	Raveled strip method: Filling	Grab method: Warp	Grab method: Filling		Warp	Filling	Warp	Filling	Warp	Filling		
	No.	No.	Lbs.	Lbs.	Lbs.	Lbs.	%	%	%	%					Ozs.	Typp	Typp	Turns per inch and direction	Turns per inch and direction	%	%	%	Rhes
GROUP I																							
U1 40		18	20.5	7.8	21.4	8.0	5.4	7.5	4.7	8.8	0.51	0.43	0.54	0.44	0.98	34.7	36.2	24 Z	25 Z	13.9	3.9	6.6	4.5
U2 50		28	24.3	10.9	21.0	12.1	5.6	4.6	10.3	5.4	.49	.39	.42	.43	1.34	33.8	40.5	24 Z	27 Z	12.2	8.9	7.0	3.8
U3 40		19	18.4	8.6	19.8	8.4	4.3	4.7	4.0	3.3	.46	.45	.50	.44	1.04	32.8	36.5	26 Z	24 Z	15.5	5.6	6.8	4.7
U4 48		21	24.2	10.4	25.3	10.2	5.1	6.4	4.6	4.3	.50	.50	.53	.49	1.24	33.1	35.7	23 Z	25 Z	12.8	5.0	7.6	3.8
U5 48		22	25.6	10.9	27.8	11.9	2.5	6.8	3.5	5.0	.53	.50	.58	.54	1.26	33.5	33.6	25 Z	26 Z	15.0	8.3	6.7	4.4
U6 46		18	26.0	8.8	27.6	9.4	5.6	10.6	3.8	6.2	.56	.49	.60	.52	1.15	32.3	35.2	24 Z	23 Z	14.4	3.9	7.8	4.4
U7 54		30	22.8	12.6	24.4	14.4	4.6	7.8	4.0	11.0	.42	.42	.45	.48	1.30	40.1	38.4	30 Z	30 Z	13.9	8.3	7.7	3.8
U8 52		32	27.0	13.4	30.7	14.2	4.8	5.5	3.1	6.9	.52	.42	.59	.44	1.51	32.2	43.5	23 Z	35 Z	13.3	16.7	8.4	4.0
U9 50		29	27.9	10.9	30.0	12.2	2.2	3.9	3.8	3.2	.56	.38	.60	.42	1.41	37.0	41.4	29 Z	32 Z	11.7	14.4	8.4	3.6
U10 50		23	27.3	11.1	30.6	11.5	3.7	3.4	2.4	7.0	.55	.48	.61	.50	1.29	33.0	37.4	25 Z	34 Z	12.8	10.0	7.4	3.8
U11 48		23	27.8	11.8	30.7	10.9	4.6	6.0	3.7	17.4	.58	.51	.64	.47	1.36	31.8	35.1	24 Z	32 Z	12.2	11.1	7.5	3.6
U12 48		21	25.9	10.6	28.0	10.5	5.1	4.3	2.8	5.9	.54	.50	.58	.50	1.25	32.9	36.5	23 Z	30 Z	12.8	14.4	6.2	3.7
U13 46		19	25.8	9.5	27.7	9.3	5.0	6.2	3.4	6.1	.56	.50	.60	.49	1.18	31.8	33.4	23 Z	35 Z	11.1	10.0	8.7	3.7
U14 46		23	24.0	11.4	27.2	12.4	3.9	3.4	5.0	2.1	.52	.50	.59	.54	1.28	32.3	33.0	24 Z	34 Z	11.7	10.0	8.6	3.6
GROUP II																							
F1 55		29	22.5	11.7	25.5	12.8	5.3	6.9	2.7	10.7	.41	.40	.46	.44	1.11	46.5	44.8	27 Z	27 Z	5.6	13.3	1.5	9.4
F2 62		33	26.2	12.2	30.4	13.5	5.0	5.3	3.1	6.2	.42	.37	.49	.41	1.18	49.8	49.1	32 Z	36 Z	5.6	14.4	1.2	5.9
F3 48		27	25.7	11.5	27.9	12.9	5.7	6.4	2.5	6.9	.54	.43	.58	.48	1.18	37.4	41.1	22 Z	26 Z	6.7	15.6	1.6	5.5
F4 48		20	32.8	9.9	35.0	11.2	4.6	7.4	4.9	5.9	.68	.50	.73	.56	1.06	36.1	40.3	22 Z	32 Z	8.3	8.3	1.9	4.4
F5 42		18	33.9	24.1	35.9	24.4	5.4	7.4	0.4	5.7	.81	1.34	.85	1.36	1.90	23.4	12.3	22 Z	10 Z	7.2	9.4	2.4	13.2
F6 48		20	26.0	9.5	29.4	10.5	3.7	5.2	1.8	5.9	.54	.48	.61	.52	1.06	39.6	37.3	21 Z	22 Z	7.8	4.4	3.3	4.3
F7 54		30	22.3	10.4	24.8	12.1	5.3	4.9	3.6	3.2	.41	.35	.46	.40	1.07	47.5	48.5	30 Z	29 Z	6.7	14.4	3.5	7.7
F8 42		19	19.0	7.0	21.0	7.8	5.6	7.0	2.4	3.6	.45	.37	.50	.41	0.89	37.4	39.8	25 Z	22 Z	8.3	4.4	3.8	4.7
F9 54		29	24.6	11.2	25.4	11.9	6.2	5.2	5.9	7.3	.46	.39	.47	.41	1.03	51.5	48.2	28 Z	29 Z	5.0	10.0	2.2	4.6
F10 46		18	29.0	8.3	31.4	9.3	4.7	6.3	4.9	1.5	.63	.46	.68	.52	1.02	36.1	34.4	21 Z	34 Z	8.9	7.8	6.0	5.9
F11 51		21	33.4	10.2	34.5	11.5	3.7	6.1	3.5	4.1	.65	.49	.68	.55	1.18	36.1	35.2	23 Z	35 Z	7.8	8.9	4.6	5.3
F12 41		18	21.9	7.2	24.5	7.4	5.2	6.9	2.9	9.2	.53	.40	.60	.41	0.92	35.3	37.4	24 Z	26 Z	10.0	6.1	5.7	6.0
F13 56		36	21.6	14.4	23.0	15.8	3.5	5.2	5.3	4.4	.39	.40	.41	.44	1.20	49.4	46.4	48 Z	47 Z	6.1	16.7	0.3	11.0
GROUP III																							
F14[9] 42		25	21.2	11.7	22.4	13.8	2.6	1.9	3.4	3.0	.50	.47	.53	.55	1.16	36.4	29.4	27 Z	No twist	18.3	5.6	5.4	8.8
F15[9] 36		19	19.6	10.0	21.2	11.0	4.1	2.4	5.0	1.8	.54	.53	.59	.56	1.02	33.0	28.4	24 Z	No twist	13.3	1.1	7.3	7.8
F16[9] 44		26	23.0	11.1	23.8	15.2	2.1	2.9	4.9	0.7	.52	.43	.54	.58	1.42	30.8	27.3	27 Z	No twist	12.8	3.3	11.7	10.2
F17[10] .. 38		24	19.8	14.0	23.3	16.8	2.2	3.0	4.1	5.3	.52	.58	.61	.70	1.22	30.9	29.7	20 S	21 S	14.4	8.3	1.4	8.3
F18[10] ... 40		25	20.5	14.0	24.3	17.4	2.1	2.4	3.2	1.6	.51	.56	.61	.70	1.26	31.4	31.6	22 S	24 S	16.1	11.1	1.0	8.3
F19[10] ... 42		28	21.2	15.2	25.7	19.4	5.7	3.0	3.0	3.6	.50	.54	.61	.69	1.39	31.1	29.5	20 S	22 S	18.3	11.1	1.3	8.4

[1] Each value for Groups I and III is the average of 10 determinations and for Group II, of 20.
[2] An average of 5 tests in each direction.
[3] Breaking strength divided by yarns per inch.
[4] For Groups I and III each value is the average of 3 determinations and for Group II, of 6.
[5] An average of 40 determinations.
[6] An average of 3 measurements made on each test fabric, in each direction.
[7] Each value is an average of 2 determinations.
[8] An absolute unit of fluidity or the reciprocal of a limit of viscosity.
[9] Cotton warp, rayon filling.
[10] Rayon warp and filling.

TABLE 2—Properties of 33 plain curtain marquisettes, after service[1]

Fabric group and number	Times laundered	Yarns per inch[2]		Breaking strength[2]		Breaking strength index[3]		Weight per square yard[4]	Fluidity[5]
		Warp	Filling	Warp	Filling	Warp	Filling		
	Number	Number	Number	Pounds	Pounds			Ounces	Rhes
GROUP I									
U1	2[6]	42	19	14.6	6.5	.35	.34	1.09	11.6
	4[7]	45	20	12.6	6.2	.28	.31	1.12	12.2
	6[7]	41	19	11.9	5.2	.29	.27	1.07	12.3
U2	2	55	30	20.7	10.4	.38	.35	1.48	10.3
	4	58	31	19.7	8.8	.34	.28	1.60	11.0
	6	55	30	17.3	8.0	.31	.27	1.45	12.4
U3	2	42	20	14.5	7.2	.35	.36	1.14	10.5
	4	44	20	13.6	6.2	.31	.31	1.14	7.6
	6	42	19	8.5	3.5	.20	.18	0.99	22.2
U4	2	52	22	16.9	8.2	.32	.37	1.38	11.7
	4	54	23	17.8	8.3	.33	.36	1.38	11.9
	6	53	22	14.0	6.4	.26	.29	1.32	18.7
U5	2	53	24	21.3	8.0	.40	.33	1.44	11.8
	4	54	24	20.9	7.3	.39	.30	1.51	11.6
	6	54	24	17.3	7.2	.32	.30	1.41	12.5
U6	2	50	19	20.7	7.2	.41	.38	1.26	10.6
	4	51	20	16.7	7.0	.33	.35	1.35	10.5
	6	49	20	16.0	6.0	.33	.30	1.21	12.8
U7	2	59	33	18.5	10.8	.31	.33	1.49	10.5
	4	62	33	17.1	9.8	.28	.30	1.57	7.8
	6	60	32	12.2	8.3	.20	.26	1.57	21.0
U8	2	58	34	25.3	11.7	.44	.34	1.61	8.1
	4	59	36	25.0	12.2	.42	.34	1.77	7.3
	6	59	35	16.2	8.2	.27	.23	1.66	19.6
U9	2	58	30	26.6	9.6	.46	.32	1.55	9.5
	4	58	31	23.5	9.7	.41	.31	1.62	9.6
	6	59	31	20.7	8.4	.35	.27	1.58	10.1
U10	2	56	24	23.0	9.7	.41	.40	1.47	9.9
	4	58	24	20.4	9.5	.35	.40	1.52	10.3
	6	58	24	20.4	8.4	.35	.35	1.50	11.7
U11	2	54	24	24.6	10.2	.46	.42	1.61	8.7
	4	56	25	23.1	8.8	.41	.35	1.57	8.6
	6	55	24	20.6	8.7	.37	.36	1.49	17.4
U12	2	55	22	22.8	9.3	.41	.42	1.45	8.4
	4	56	23	22.2	8.4	.40	.37	1.53	7.2
	6	55	22	17.9	6.3	.33	.29	1.42	17.9
U13	2	51	20	20.6	7.4	.40	.37	1.27	13.0
	4	52	21	18.1	7.6	.35	.36	1.37	9.7
	6	52	21	17.6	6.5	.34	.31	1.27	11.3
U14	2	52	24	19.6	9.2	.38	.38	1.35	13.2
	4	55	25	21.8	9.5	.40	.38	1.46	9.6
	6	52	24	17.3	7.9	.33	.33	1.41	14.5
GROUP II									
F1	2	62	31	19.9	8.9	.32	.29	1.28	18.8
	4	62	31	19.4	9.1	.31	.29	1.32	17.5
	6	62	31	15.0	6.5	.24	.21	1.23	26.9
F2	2	70	35	24.3	10.3	.35	.29	1.40	16.3
	4	71	35	22.8	9.8	.32	.28	1.41	12.2
	6	71	35	19.9	7.4	.28	.21	1.32	21.4
F3	2	53	30	20.0	9.1	.38	.30	1.39	18.7
	4	54	30	19.5	8.0	.36	.27	1.39	15.5
	6	54	29	18.3	8.0	.34	.28	1.37	21.0
F4	2	54	21	23.8	7.0	.44	.33	1.26	18.4
	4	54	22	24.4	7.2	.45	.33	1.27	15.0
	6	54	21	21.1	7.0	.39	.33	1.23	18.6
F5	2	44	20	29.8	22.8	.68	.11	2.29	20.2
	4	44	20	28.8	21.8	.65	1.09	2.23	17.2
	6	42	19	20.8	15.4	.50	.81	2.15	28.0
F6	2	52	22	20.7	8.3	.40	.38	1.25	13.0
	4	53	22	19.0	7.7	.36	.35	1.27	11.2
	6	51	22	14.0	5.8	.27	.26	1.20	21.8
F7	2	60	32	18.7	9.2	.31	.29	1.23	16.4
	4	60	33	18.4	8.6	.31	.26	1.25	14.7
	6	60	32	12.8	5.8	.21	.18	1.18	25.7
F8	2	44	20	14.0	5.4	.32	.27	1.03	20.8
	4	46	20	13.1	4.8	.28	.24	1.03	16.7
	6	46	20	11.8	4.6	.26	.23	1.00	22.3
F9	2	61	31	23.6	10.4	.39	.34	1.22	13.9
	4	60	31	22.2	10.1	.37	.33	1.26	10.7
	6	60	30	17.9	7.0	.30	.23	1.16	21.2

(Continued on Next Page)

for most of the finished fabrics exceeded that for the majority of unfinished materials. However, at the end of a year's service eight marquisettes in Group II and two in Group III still had a warp strength of 15 pounds or more. Seven of the finished cotton materials and three of those with a rayon weft met the 7-pound criterion for crosswise strength. These minima represented a little more than 65 and 60 per cent of the new warp and filling strength, respectively.

An analysis of variance of the breaking strength data for marquisettes in Group I showed that the two sources of variation, fabrics and service, were significant in both the warp and filling directions (Table 3). According to individual comparisons (based on the analysis of variance) for fabrics, marquisettes U_1 and U_5 were significantly lower in warpwise and fillingwise strength than all the other pieces but were not definitely different from each other. Fabrics U_2, U_3, U_6, U_{13}, and U_{14} differed significantly in warp strength from others in the group but not among themselves. The same was true of fabrics U_8, U_{10}, U_{11}, and U_{12}. In crosswise strength fabric U_5 was significantly higher than any other unfinished cotton marquisette. Fabrics U_2, U_7, U_9, U_{10}, U_{11}, and U_{14} also differed significantly in fillingwise breaking strength from the rest of the group but not from each other. Individual comparisons showed that all relationships between breaking strength in either direction for any two periods of service were significant (Table 4).

In Group II, as in Group I, both fabric and service were found to be significant factors in breaking strength. Fabrics F_1, F_3, and F_6 showed no significant difference from each other in either warp or filling breaking strength. They were, however, significantly different from the rest of the group. The same was true of fabrics F_2 and F_9. Fabric F_5 was definitely stronger in both directions than the other finished cotton marquisettes and fabric F_8 was significantly lower in fillingwise strength. All differences between any two test periods except that between two and four launderings were significant in the warp and filling strength (Table 4).

For Group III, fabric was a significant factor for the filling but not for the warp strength whereas service was significant for both test directions (Table 3).

When the grab method was used to determine breaking strength, the values obtained for the unfinished materials as a group were 7 and 5 per cent higher for the warp and filling, respectively, than when the strip method was used. The grab values for the finished cotton materials exceeded the strip by 9 per cent in both the warp and filling directions.

TABLE 2—Continued

F10	2	51	19	22.3	6.7	.44	.35	1.17	12.2
	4	52	20	21.2	7.0	.41	.35	1.20	11.1
	6	51	19	16.2	5.2	.32	.27	1.13	19.0
F11	2	56	23	23.5	7.9	.42	.34	1.32	17.3
	4	57	23	23.8	8.1	.42	.35	1.43	12.3
	6	58	23	22.2	7.6	.38	.33	1.34	15.7
F12	2	44	19	14.7	5.2	.33	.27	1.02	19.6
	4	46	19	15.4	5.4	.33	.28	1.07	12.2
	6	45	19	13.6	4.4	.30	.23	1.02	16.9
F13	2	63	39	17.6	12.0	.28	.31	1.46	23.4
	4	64	39	18.1	12.2	.28	.31	1.49	20.4
	6	62	38	12.7	8.4	.20	.22	1.40	27.3
GROUP III									
F14	2	48	27	14.6	11.2	.30	.41	1.30	10.4
	4	48	28	14.7	7.2	.31	.26	1.44	9.7
	6	47	27	12.6	5.5	.27	.20	1.37	11.1
F15	2	42	20	15.6	10.0	.37	.50	1.19	10.6
	4	41	21	14.2	11.4	.35	.54	1.20	9.7
	6	40	20	11.2	4.8	.28	.24	1.07	14.5
F16	2	48	28	17.0	6.6	.35	.24	1.49	12.6
	4	49	29	14.0	10.7	.29	.37	1.67	12.3
	6	47	28	9.1	3.8	.19	.14	1.42	16.9
F17	2	43	26	17.7	11.9	.41	.46	1.48	11.2
	4	43	27	18.4	13.0	.43	.48	1.57	10.5
	6	43	25	14.2	8.1	.33	.32	1.44	14.9
F18	2	43	27	13.8	8.5	.32	.31	1.48	13.2
	4	43	28	19.0	13.1	.44	.47	1.55	12.6
	6	42	27	15.1	11.3	.36	.42	1.48	13.8
F19	2	47	31	16.9	13.9	.36	.45	1.71	12.8
	4	48	33	19.4	14.9	.40	.45	1.71	11.5
	6	46	31	16.8	13.0	.37	.42	1.69	13.3

[1] Periods of service designated by times laundered.
[2] Each value for Groups I and III is the average of 10 determinations and for Group II, of 20.
[3] Breaking strength divided by yarns per inch.
[4] For Groups I and III each value is the average of 3 determinations and for Group II, of 6.
[5] An absolute unit of fluidity or the reciprocal of a limit of viscosity.
[6] Curtains in use four summer months, May through August.
[7] Curtains in use eight fall, winter and early spring months, September through April.
[8] Curtains in use a full year, May through April.

TABLE 3—Analysis of variation in the yarn count, breaking strength, and weight per square yard of plain curtain marquisettes

Fabric group	Source of variation	Degrees of freedom	Mean square variance				
			Count		Breaking strength[1]		Weight
			Warp	Filling	Warp	Filling	
I	Fabric	13	1,026.11**	1,022.31**	436.52**	87.08**	0.67**
	Washes	3	1,265.20**	103.17**	1,762.12**	299.62**	0.71**
	Error[2]	39	10.42	0.91	16.38	3.28	0.012
II	Fabric	12	4,599.21**	3,632.52**	1,277.42**	1,234.26**	2.02**
	Washes	3	1,986.37**	181.03**	3,892.29**	767.00**	0.73**
	Error[2]	36	19.33	0.94	47.18	19.08	0.0083
III	Fabric	5	336.8**	507.7**	69.06–	217.31**	0.76**
	Washes	3	358.9**	105.9**	618.79**	208.09**	0.51**
	Error[2]	15	5.3	2.4	37.82	29.47	0.02

[1] Strip method.
[2] Interaction Fabric X Wash.
** Indicates highly significant variation.
– Indicates no significant variation.

TABLE 4—Individual comparisons of the effect of service[1] upon plain curtain marquisettes

Fabric group	Fabric property	Mean square (variance) for periods being compared[2]					
		Number of washes					
		0 and 2	0 and 4	0 and 6	2 and 4	2 and 6	4 and 6
I	Warp breaking strength..	1,221.0**	1,883.4**	5,195.3**	71.5*	1,379.1**	822.5**
	Filling breaking strength.	183.9**	321.9**	877.9**	19.2*	258.2**	136.6**
	Warp count	1,882.4**	3,250.4**	2,150.6**	185.6**	8.9–	113.2**
	Filling count	126.2**	292.1**	137.2**	34.3**	0.2–	28.9**
	Weight per square yard..	0.96**	2.00**	0.57**	0.20**	0.05–	0.45**
II	Warp breaking strength..	3,404.3**	3,989.4**	11,380.8**	23.2–	2,417.9**	1,965.6**
	Filling breaking strength.	445.8**	597.9**	2,287.3**	11.1–	713.5**	546.3**
	Warp count	353.6**	4,596.4**	3,662.3**	69.4–	1.1–	53.0–
	Filling count	332.2**	457.9**	239.6**	9.4**	8.1**	35.0**
	Weight per square yard..	1.44**	1.81**	0.88**	0.02–	0.07**	0.17**
III	Warp breaking strength..	7,380.4**	5,633.3**	18,096.3**	158.4–	2,363.2**	3,536.3**
	Filling breaking strength.	160.3*	21.8–	729.6**	50.0–	226.0*	498.9**
	Warp count	681.6**	907.5**	433.2**	16.1–	28.0*	86.7**
	Filling count	116.0**	313.6**	100.8**	48.1**	0.53–	58.8**
	Weight per square yard..	.74**	1.40**	0.52**	0.12*	0.02–	0.23**

[1] Periods of service designated by number of washes.
– No significant difference.
* Indicates significant difference.
** Indicates highly significant difference.

The correlation between the warp and filling breaking strength, as determined by the strip and grab methods, respectively was unusually high—0.98 for the warp and 0.99 for the filling. As a result the grab breaking strength for finished all-cotton marquisettes could be estimated with a high degree of accuracy from the test data obtained by the strip breaking strength procedure and vice versa. For example, when the warpwise grab breaking strength was calculated[a] by the method of least squares *(11)* from the warp strip values and the results compared with the grab values obtained from the fabric, the standard error of estimate was only 0.96 pounds. An even smaller standard error of estimate (0.4 pounds) was found when the fillingwise grab breaking strength was calculated from the strip values and the results compared with those obtained in the laboratory. These same errors of estimate were found when the corresponding strip values were calculated from the grab breaking strength data.

Yarns Per Inch

The warp count for new marquisettes in Groups I, II, and III varied from 40 to 54, 41 to 62, and 36 to 44 with an average of 48, 49, and 40 yarns to the inch, respectively (Table 1). Fillingwise, the corresponding ranges for the three groups were 18 to 32, 18 to 36, and 19 to 28 with a mean of 23 for the unfinished materials and 24 for Groups II and III.

With washing, all fabrics had an increase in the number of warp and filling yarns per inch, the maximum count occurring in most fabrics at the end of the fourth laundering. The unfinished cotton marquisettes had the largest warpwise gain, an average of 14.3 per cent. An increase of 12 per cent in the number of filling yarns per inch for materials in Group III exceeded the gain in the two other groups. On the whole, the minimum gain in the number of yarns per inch occurred at the second washing. In a few materials the count after the sixth laundering was less than after the second but in only the warp count of one marquisette, F_2, was it as low as the count of the new fabric.

An analysis of variance revealed that, as in breaking strength, both fabric and service were significant sources of variation of all three groups, warpwise as well as fillingwise (Table 3).

Weight

As a group, the new, unfinished cotton marquisettes were the heaviest fabrics.

[a] To obtain the calculated values the following equations were used:
Grab breaking strength from strip values
Warp = 0.98 strip + 2.8 pounds
Filling = 0.96 strip + 1.5 pounds
Strip breaking strength from grab values
Warp = 0.99 grab — 2.0 pounds
Filling = 1.03 grab — 1.4 pounds.

They varied from 1.0 to 1.5 ounces per square yard, the mean being 1.3 ounces. The Group III materials were next with a range of 1.0 to 1.4 ounces to the square yard and an average of 1.2 ounces. The finished, cotton fabrics were the lightest, weighing on the average 1.1 ounces per yard square.

With laundering, all marquisettes increased in weight per square yard reaching the maximum, for the most part, with the fourth wash. This parallels the finding that the highest warp and filling count for all groups occurred with the fourth laundering. On the whole, at the end of the study the fabrics weighed less per square yard than at the end of the second and fourth washing, but more than when new. During the first 8 months of service, shrinkage resulting in a greater number of warp and filling yarns per inch evidently offset the effects of wear so far as weight was concerned, but during the last 4 months of use the effect of wear had overcome some of this gain.

Both fabric and service were significant sources of variation for all groups, according to an analysis of variance of the weight data (Table 3). Of the unfinished materials, U_5 was the heaviest and the only piece in the group greatly different in weight from any of the others. In Group II, fabric F_5 was definitely heavier than any other finished cotton marquisettes whereas fabrics F_8 and F_{12} were lighter than the others. These three materials were the only ones significantly different from the rest of the group. Of the fabrics containing rayon, materials F_{16}, F_{17}, and F_{18} showed no significant difference. The other marquisettes in Group III were not only different from these three but also from each other.

All comparisons with respect to weight, between any two periods of service for Groups I and III were significant except that between two and six washes (Table 4). Apparently the loss in weight due to service after six launderings was enough to compensate for the gain in weight due to shrinkage after two washes. In Group II, all comparisons for service between any two periods were significant except that between two and four washes.

Fluidity in Cuprammonium Hydroxide

The fluidity values for the cotton materials in Group I ranged from 3.6 to 4.7 rhes (Table 1). For fabrics in Group II, the range was from 4.3 to 13.2 rhes with majority between 4.3 and 6.0 rhes. The lower fluidity for the unfinished materials was to be expected since bleaching processes deteriorated cellulose. The materials in Group I, with the small fluidity range of only 1.1 rhes, had not been subjected to any treatment which would impair them chemically to any appreciable extent. In contrast, the finished fabrics with a range of 8.9 rhes had all been partly or fully bleached. The fluidity values for the all-rayon fabrics and the rayon portion of the three cotton and rayon materials in Group III varied from 7.8 to 10.2 rhes.

The actual range of fluidity values was greater for each group of fabrics after service for 1 year than when the materials were new and the increase in fluidity was more rapid during the first months of service than later (Table 1). However, the increase, in general, was less for the unbleached marquisettes than for the bleached cottons.

As a rule, fabrics having a high fluidity after a year's service also had a large percentage loss in breaking strength. Similarly, those materials with a small fluidity value showed a relatively small loss in strength during the year's time.

Shrinkage

Shrinkage for all the unfinished marquisettes exceeded 11 per cent in the warp direction (Table 1). Fillingwise, half of the materials shrank 10 per cent or more. Of the fabrics finished for the consumer market all those in Group II shrank between 5 and 10 per cent in the warp direction. The fillingwise shrinkage varied from 4 to 17 per cent, exceeding 10 per cent for 6 of the 13 materials. For all fabrics containing rayon, warp shrinkage was at least 13 per cent. In fabrics F_{14} and F_{19} it was 18 per cent, which was equivalent to 6.5 inches per yard. In the filling direction, the shrinkage for the Group III materials ranged from 1 to 11 per cent, with only two fabrics under 5 per cent. A higher shrinkage in the filling than in the warp direction for the finished cotton marquisettes and a greater warpwise than fillingwise shrinkage for the all-rayon materials concurs with the findings of Petzel *(9)*.

CONCLUSIONS

Results of this study indicate that, from the standpoint of serviceability, marquisettes woven from fine single yarns is an unsatisfactory glass curtain material. However, if a consumer prefers this type of material to a more sturdy fabric she should, for best wear, select a finished marquisette made entirely of cotton or an all-rayon fabric woven from continuous filament yarns having considerable twist, in preference to one with a rayon filling of continuous filament yarns having little or no twist or to one having a spun rayon filling. The breaking strength index (strength divided by count) for fabrics having a weft of continuous filament rayon with little twist or of spun rayon was considerably lower than for fabrics having highly twisted continuous filament rayon yarns in the filling.

High count (50 yarns to the inch in the warp and 25 in the filling), all-cotton marquisettes made from single yarns with a relatively large twist factor, will outwear similar materials having fewer, less tightly twisted, coarser, single yarns.

From the rayon marquisettes studied, it appears that those having 40 or more continuous filament yarns with considerable twist in the warp and 25 like yarns in the filling will give better service than similar materials woven from continuous filament yarns having little or no twist or from yarns spun from staple fiber.

A high shrinkage is to be expected in curtain marquisettes. It would seem advisable to make an allowance of 2 to 2½ inches for each yard in length when making curtains from a high-count, all-cotton fabric and of 5 to 6½ inches per yard length when using a fine, all-rayon material.

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MOISTURE RELATIONS

(Concluded from Page 327)

its regain, observed a striking resemblance between the variations in the dimensions of the cotton hairs and the variations in the water absorbency with the concentration of mercerizing liquor. Thus, concentrations of mercerizing liquor causing maximum swelling of the cotton also conferred maximum hygroscopicity. Further, the ratio between the moisture content of mercerized and unmercerized cotton at the same humidity, termed the "mercerization ratio," was independent of the degree of that humidity. All these results indicated that mercerization increases the accessible surface of cotton in proportion to the "mercerization ratio." They also demonstrated that cotton mercerized under tension was considerably less hygroscopic than cotton mercerized without tension, this difference of hygroscopicity being achieved by the application of only a small tension to the yarn.

Curves showing the relationship between the hygroscopicity of mercerized yarn and the concentration of the mercerizing solution showed maxima with 25 per cent and 15 per cent solutions (caustic soda), and a minimum of 20 per cent in the case of mercerization without tension, whereas, when tension was applied, only one maximum was shown, viz. at 25 per cent, although it was thought that a point of inflexion must exist between 20 per cent and 25 per cent.

A series of experiments[52] on the absorbency of a piece of cotton cloth subjected to the normal routine of a bleach works showed that, while specific effects were apparent at very high humidities, the trend of the hygroscopicity change was in general downwards from the malted stage to the fully bleached cloth, unless the cloth was mercerized before the bleaching stage, in which case the absorbency showed an increase at this point. The variations caused by dyeing are small, relative to the differences that may be caused in any one sample by changes in pre-history. Chemical attack is also instrumental in reducing the hygroscopicity of cotton, but the reduction is small, except in cases where degradation is great enough to cause almost complete loss of tensile strength.

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ABSTRACTS FROM CONTEMPORARY JOURNALS

ANNUAL MEETING, SOCIETY OF DYERS AND COLOURISTS, Journal of the Society of Dyers and Colourists, page 137, No. 6, Vol. 61, June, 1945.

The 61st annuad meeting of the Society of Dyers and Colourists was held on March 23rd, 1945. A condensation of the report of this meeting might be of interest to readers of the Reporter, particularly those who are members of the A.A.T.C.C.

The Council of the Society reported 90 new members, 20 new junior members and 2 new associate members. During 1944 35 sectional meetings had been held. Reference was made to the proposed Royal Charter for the Society, the production of a new *Colour Index*, reorganization of the Fastness Tests Committee, and the completion by a sub-committee of draft regulations for admission by examination and practical test of students to a qualification whch would be described as an Associateship of the Society. It was also reported that all Communications are refereed before publication in the Society's journal.

The treasurer reported that there was a surplus for the year of £452. This from an income of a little over £5080.

FINISHES FOR RAISED CLOTH, The Dyer and Textile Printer, page 476, Vol. XCIII, No. 12, June 8, 1945.

A special type of softener may be used on light woven or knitted fabrics, and certain styles of sheetings and flannelettes, before the actual raising to provide a full, soft and lofty handle. This softener is usually based on one of the sulfonated higher fatty alcohols. This is furnished in the form of a wax which is easily emulsified with warm water. It is applied by passing the cloth through a bath or by padding.

The author states that soaping is sometimes used but there is a tendency for the goods to be dry and harsh, may acquire a tacky handle, may discolor light or white shades and may give an objectionable odor.

The use of the softener mentioned may replace or reduce the usual necessary starch, dextrine and sulfonated filling. Where filling is necessary, the softener works well in conjunction with starch, dextrine or kaolin. The softener will also reduce the tendency of the threads to slip. Most of the softeners of the type mentioned have all of the characteristics of the

product on which they are based: penetrating and wetting-power, dispersing ability, freedom from lime-soap formation in the presence of hard water.

TWO-COLOUR DYEING OF ALL-WOOL MATERIALS, F. Townend, *Journal of the Society of Dyers and Colourists*, page 144, Vol. 61, No. 6, June, 1945.

This paper is concerned with the dyeing properties of mixtures of chlorinated wool and normal wool. Some suitable fiber mixtures for two-tone effects and their possibilities are given in Table I.

TABLE I

Suitable Fiber Mixtures for Two-Tone Effects
(Heavy Dyeing Component First)

Mixture	*Comments*
(A) Chlorinated wool and normal wool	May cockle in wet treatments and will felt in laundering.
(B) Chlorinated wool and chlorinated resisted wool	Will neither cockle in wet treatments nor felt in laundering.
(C) Normal wool and resisted wool	Will not cockle in wet treatments. Unsuitable for garments which are to be laundered, but suitable for cloths to be milled. Dyeing properties differen from (A).
(D) Alkali - treated wool and normal wool	Processing properties similar to (C), with dyeing properties similar to (A).

The traditional method of producing tone-in-tone effects is by the selection of certain dyes which are fast to wet processing: chrome dyes, acid milling dyes, direct cotton dyes. A dye is selected with a slow rate of dyeing on normal wool, or a dyeing method is selected which will give the same result. The tone-in-tone effect may be controlled to some extent by adjusting the pH value of the dyebath but, in general, it is an intrinsic property of the dye. The degree of contrast obtained is due to the property of the dyestuff.

Difficulties resulting from the traditional method of obtaining tone-in-tone effects are said to be: "If a mixture of two or more dyes is used, it is very likely the result will not be, a tone-in-tone effect, but an unattractive off-tone contrast. The dyes are moreover rather dull for certain trades, and there is a general lack of variety of good blues and greens. . . . Another difficulty lies in the fact that exhaustion and, consequently, build-up properties are both poor."

A new method of producing tone-in-tone effects has been the use of level dyeing acid dyes with a retarding agent. With level dyeing acid dyes, it is not effective to increase the pH of the dyebath to produce the desired contrast. Hence the use of a retarding agent. A list of level dyeing acid dyes which give no-contrast, fair contrast, good contrast and excellent contrast is included. In general the degree of contrast is increased as the number of sulfonic groups in the dye increases. A full shade-range can be obtained, either by dye selection, or by varying the amount of retarding agent used. The paper goes into considerable detail as to the theoretical considerations involved.

Another new method of producing tone-in-tone effects is the use of a retarding agent in conjunction with dyes which are fast to wet processing. With chrome dyes, the chromate method is replaced with the afterchrome method with the use of a retarding agent. This is said to give good exhaustion, stronger contrasts and the dye is locked into position by the chroming operation. A list of chrome dyes which give no contrast, fair contrast and good contrast by the afterchrome process in the presence of retarding agent is included.

Advantages of these two new methods of producing tone-in-tone effects by the use of a retarding agent are given as follows: (1) greater choice of dyes; (2) increased number of dyeing methods available; (3) control of degree of contrast by adjusting amount of retarding agent used; (4) if desired, great improvement in degree of contrast; (5) increased control over final result because of good dyebath exhaustion; (6) consequent reduced dye cost.

The mechanics of these processes are simple. In the case of level dyeing acid dyes, the retarding agent was added to the normal sulfuric acid dyebath. In the case of dyes fast to wet processing, the retarding agent slowed down the dyeing to such an extent that it was necessary to use 1 per cent sulfuric acid in place of acetic acid to give good exhaustion. (The retarding agents used by the author in his experiments were identified as : Lissatan AC [made by condensing a naphthalene sulfonic acid with formaldehyde]; Taninol WR [a complex phenol-sulfur condensate which is subsequently air-oxidized].

FACTORS WHICH INFLUENCE THE COLOUR AND FINISH OF VISCOSE RAYON KNITWEAR, "Midlander," *Silk Journal and Rayon World*, page 33, Vol. XXI, No. 252, May 1945.

This article mentions a number of processing operations that should receive attention in order to produce a satisfactory fabric.

Oil stains, present in the fabric as delivered to the dyer, should be removed before dyeing either by a thorough hot soap scour or by sponging with a stain remover.

Holes or damages due to faulty knitting should be mended before the scouring which is invariably carried out in a winch machine, perferably having a deep rather than a shallow vat. The machines should be of stainless metal holding up to twenty pieces which run singly side by side separated by a peg rail.

The soap scouring liquor should be kept at a high temperature by heating with steam. A high concentration of soap in a short bath should be used.

Soft water is essential in the rinsing operation. Where hard water can not be avoided it is recommended that a soap substitute be used which will not form insoluble products with the lime and magnesium salts. Warm to hot water is recommended for the first wash when these products are used.

A small amount of soda ash may be used in the scouring operation if necessary but it should be used carefully as it may have a harshening effect on the fabric.

If a fabric is yellow after the scouring operation it should be bleached before dyeing with a minimum amount of sodium hypochlorite.

It is not usually necessary to follow the bleaching with an antichlor treatment as the soap liquor in which the dyeing is usually carried out acts somewhat as an anti-chlor. Overbleaching is to be avoided because of the danger of formation of oxycellulose.

If the bleached fabric is not to be dyed then it is advisable to destroy residual chlorine by a light soaping or the use of sodium bisulfite.

STRIPPING AND REDYEING COTTON PIECE GOODS, The Dyer and Textile Printer, page 509, Vol. XCIII, No. 13, June 22, 1945.

A number of suggestions are given for removing dyestuffs of the various classes:

Direct Colors—Boiling with water may remove enough color to allow redyeing. Most direct colors may be removed by chemicking, but care must be exercised to prevent tendering. Hot alkaline reduction in caustic and hydros* solution is most satisfactory for stripping direct colors. In case there is a residual color it may be necessary to treat the cloth with a discharging agent. Titanous chloride and titanous sulfate are recommended for this purpose in removing yellows.

Basic Colors—The dyed cloth is boiled in caustic soda solution. A second boiling is sometimes advisable and a light chemick may be needed to brighten the ground. For brightest results finish the treatment with a soaping and rinsing.

* We are not familiar with this term but assume it refers to hydrosulfite.

Sulfur Colors—Boil the cloth out in a mixture of sodium sulfide, caustic and hydros in a long bath, followed by a thorough rinsing. A more complete strip may be obtained by chemicking.

Mineral Khakis—Boil the material in an oxalic acid solution, rinse in water, mild alkali, and more water.

Vat Dyeings—Usually a complete strip is not possible. It requires a good deal of care and experience to attempt to bring down the color on vat dyeings. A portion may be removed in a hydrosulfite and caustic soda bath, with caution being exercised to prevent disintegration of the material. A more rapid strip may be obtained by using a vat retarding agent in the stripping bath. Another patented method involves the use of magnesium chloride and a protective colloid in a hot alkaline reducing bath. Special vat stripping agents are on the market.

Azoic Colors—A strong reducing bath of caustic and hydros is used at the boil. A proprietary stripping agent is available. When the boiling reduction has been completed, the yellow residue may be removed by chemicking.

ELECTRONIC CONTROL OF CLOTH-DRYING MACHINERY, N. H. Chamberlain, *Textile Manufacturer*, page 163, Vol. 71, No. 844, April, 1945.

Cloth driers running at constant speed cannot cope with changing amounts of moisture present in the material. To make certain that the wettest portions are dried down to the required regain it is necessary to over-dry the driest portions. It is then necessary to recondition the fabric to bring it up to the proper moisture content. Such a procedure results in a low output for the drying machine. Further, textile fabrics suffer some deterioration in quality when subjected to overheating and overdrying.

Any device to control the moisture content of the cloth at the delivery end would consist of a detector unit and a control unit. The detector unit would convert variations of moisture content of the material as it passes some given point into fluctuations in some other quantity (electric current, voltage, position of lever, etc.) The control unit would respond to this and affect the running of the machine such as changing speed, amount of heat being delivered, etc.

A number of detector units and their advantages and disadvantages are discussed. Among them are: adaptation of the ordinary hair hygrometer; electrical resistance detector; capacity detector (air condenser). The use of the thyraton valve as a control unit is discussed.

The author points out that electronic control is at present almost completely unknown in the textile industry, although it is widely used in others, e.g., paper making and printing. Moving parts of an electronic control are kept to a bare minimum and hence mechanical breakdowns are rare. Electrical breakdown, given good design, is also rare. Valves have an average useful life of 500 hours and replacement is but a few seconds work.

In conclusion the author says: "The case of drying machinery is only one example, possibly the most obvious, of the need for such controls. Many others could be found at all stages of textile processing. The possibilities of greater output, cheapened production, and higher quality which are inherent in controlled manufacturing methods should, at a time when potential post-war developments make all three the more desirable, bring the possibility of more and better control methods into the forefront of any manufacturer's consideration."

• TRADE NOTES • NEW PRODUCTS •

• ENGINEERS' DIGEST

In order to contribute to a better knowledge and appreciation of American scientific and engineering achievements throughout the English speaking world, the British Edition of "The Engineers' Digest" will publish in two of its monthly issues a series of articles on the most important American scientific and engineering developments during World War II. The full editorial contents of both the October and November issues of the British Edition of "The Engineers' Digest" will be devoted to technical articles of eminent American scientists and engineers, dealing with recent American technological developments.

Contributions which will be treated strictly in accordance with their editorial merits, can be sent to the Managing Editor, "The Engineers' Digest," One Madison Avenue, New York 10, N. Y.

No advertisements from American firms can be accepted.

• NEW CALGON BOOKLET

"Calgon Data for the Textile Chemist," a new booklet that goes fully into the uses of Calgon in the textile industry, has just been issued by Calgon, Inc., of Pittsburgh. The booklet gives general data on Calgon and its uses in washing, scouring, bleaching and dyeing, as well as specific applications of the chemical in wool, silk, cotton, rayon and hosiery processing. All of the applications have been mill tested, the company says.

Calgon, a dehydrated phosphate glass made from food-grade phosphoric acid, can be used safely in all wet processes, the booklet declares. It is harmless to the human skin and hair and equally harmless to all textile fibers. For use in the textile industry it is available in two forms, one applicable in all processes where no alkalinity is desired and a neutral soap is not used, and the other form when a neutral soap is used and a slight alkalinity is needed. Calgon will dissolve in cold or lukewarm water to make a stock solution in about one hour.

Not only will Calgon prevent the precipitation of soaps, oils, finishes, sizes and dyes in textile processing, the booklet says, but even when so-called naturally soft or zeolite softened waters are used a few parts per million of the chemical will prevent the water from attacking the iron pipe lines and thus picking up iron that affects bleaching and dyeing. Calgon not only will keep iron out of the water, it is said, but will control iron already in it, resulting in the brightening of shades, improvement of color fastness, reduction in iron stains, and saving of peroxide in bleaching. It is said to be of particular value in processing fabrics to be rubberized since it controls the manganese that may be present in the water.

Calgon permits soap to be used in any process water with no precipitation by lime or other metallic salts, the booklet points out. The detergent, emulsifying and dispersive properties of soap are greatly improved through Calgon, and thus soap's only faults are corrected. Since Calgon does not increase the alkalinity of any soap solution it can be used with less danger on the more delicate woolen and acetate fabrics.

• RICHMOND MOVES HEADQUARTERS

The Richmond Oil, Soap and Chemical Company has moved to larger quarters, after twelve years at its old location 153-55 Richmond Street. The new building is many times larger with the front at 1041-43 Frankford Avenue and running to Sarah Street where the address is 1026-38, Philadelphia.

The company was formed in 1933 to manufacture a line of chemical specialties for the entire textile trade, covering both the natural and synthetic fibers. Many new products have been developed in its laboratories. One feature is the development of a low temperature curing resin for shrink and wrinkle proofing. After-Chlor used by Bleachers; Dyetex, a scour for the removal of wax and prevention of spots; Rayosoft for better Rayon Yarn

dyeing, Bostex and many others have also been developed. Some other well-known products are Polylubes, a non-drip lubricant for machinery; Richine C, used by restaurants in washing and sterilizing dishes and glassware, etc. Many products are developed for the individual needs and special uses of its clientele.

Among the new projects planned is the extension of the research laboratories along with a pilot plant as part of the post-war planning.

William Alkus, Vice-President of the company, is the chief engineer and instrumental in developing the new products. He is a graduate of the University of Pennsylvania, where he taught for several years in the Chemical Department. He spent several years in the Dupont Laboratories and various other laboratories before organizing the Richmond Company.

● ARIDYE BOOKLET

Dyeing and Printing Spun Rayon is the title of No. 3 of a series of booklets on Aridye Pigment Colors for the Fabrics of Tomorrow. This booklet, which has just been issued by Aridye Corporation, Fair Lawn, N. J., describes the methods which have been developed for applying resin-bonded pigment colors to spun-rayon fabrics for dress goods, sportswear, suitings, slacks, shirts, blouses, draperies, and other apparel and household uses. Nos. 1 and 2 in the series outlined the dyeing and printing of Fiberglas and Nylon.

● GRADUATED "IN ABSENTIA"

H. B. Walker, formerly in charge of Rohm & Haas Company's Leather Finishes Department, and now head of the Textile Research Laboratory for the same company, graduated "in absentia," with the degree of Doctor of Science at the graduation ceremonies of the University of Edinburgh, June 22nd.

Doctor Walker served from 1941 to 1943 on the Council of the American Leather Chemists Association and was also active in the affairs of the Association's Physical Testing Committee. He received his B.Sc. degree, summa cum laude, from the University of Edinburgh in 1926. The research which led to his doctorate was a study of the mechanism of emulsion polymerization of acrylic esters.

● CALCO BULLETIN

Calco Chemical Division, American Cyanamid Company, Bound Brook, New Jersey, announces the release of their latest Technical Bulletin No. 773, entitled "Statistical Analysis of Test Data," by E. I. Stearns, of their Research Department.

This bulletin is intended to arouse interest in statistical methods for quality control in production and the analysis of experimental data. It is instructive in pointing out fields of application but does not include detailed mathematical methods.

This paper was originally presented as one of a series of lectures to the scientific and supervisory personnel at the Bound Brook plant of the Calco Chemical Division, American Cyanamid Company. The interest with which this lecture was received has prompted the management to make it available to the customers and friends of the company.

This bulletin may be obtained from your Calco representative, or by addressing your request to the Advertising Department, Calco Chemical Division, Bound Brook, New Jersey.

● REJOINS IMPREGNOLE

Bernard J. Miller who, as noted in our last issue, has rejoined Impregnole Corporation.

● NEW "KARBATE" COUPLINGS

The National Carbon Company has now perfected four new "Karbate" pipe connections for use in the chemical and process industries.

The "Karbate" chemically resistant pipe connections are made of impervious carbon or graphite, and possess the mechanical strength, and the resistance to thermal shock and corrosive liquids and gases which are characteristic of all "Karbate" specialty products.

Type FC is a flexible coupling particularly suited to field installations or any pipe run connecting one phase of the process with another, as it eliminates the use of cements in joining lengths of pipe. The FC coupling permits sufficient pipe movement to meet all conditions encountered in the average plant.

Type V flanged connections are said to offer all the advantages of the Van Stone type of flanges. Thickness and sturdiness of the small diameter collars provide a construction which may be used with companion flanges of almost any design or material. Separate cast iron split flanges permit easy pipe alignment and installation.

Type V nozzles and Type SC slotted couplers now available are usually factory-installed, and are particularly recommended for use on tanks, towers, heat exchangers and similar equipment.

The four new "Karbate" connections are designed to meet the widest range of pipe requirements throughout the process and chemical industries.

● TO RELAX DYESTUFF CONTROLS

Recommendation that dyestuff controls be partially relaxed to allow dyestuff consumers to increase their color quotas for civilian use was made to the War Production Board by the Dyestuff Industry Advisory Committee at a recent meeting.

The committee proposed that the agency amend M-103, the dyestuff conservation order, to permit dyestuff consumers to increase their Class A and B dye allotment immediately to 25 per cent of their total Class A and Class B dye purchases in the 1941 base period. The limitation has been 10 per cent, with no Class A dyestuff permitted for civilian use.

The recommended change would make available a dyer's entire color allotment in Class A dyestuff if he so desired, the committee said. They emphasized that the relaxation of restrictions on Class A colors, which have been reserved for the military, would be for the third quarter only.

The committee further proposed increasing the quotas on Class C dyes from 10 per cent to 17½ per cent and Class D dyes from 15 per cent to 20 per cent. All percentages are calculated on purchases made during the 1941 base period.

The proposals, WPB said, will be given immediate consideration, and an amendment issued about August 1. It will be retroactive to July 1.

The recommendations resulted from Army cutbacks that released a quantity of herringbone twill for civilian use. The committee said that any fabric processor who has twill on hand but has insufficient coloring matter to prepare it for civilian use may obtain relief by applying for authorization direct to the Textile, Clothing and Leather Bureau, WPB, Washington 25, D. C.

● FOLDER ON ESTEROL

A new 4-page technical folder released by the Textile Chemicals Division of L. Sonneborn Sons, Inc., New York, describes various wet processing applications of Esterol, a concentrated synthetic wetting and rewetting agent.

The folder explains many of the advantages in the use of Esterol for Sanforizing, vat dyeing, general dyeing operations, worsted fulling, and warp-sizing

of rayons. Kier boiling of certain types of cotton goods, such as poplins and herringbone twills, it is stated, may be eliminated by the use of Esterol. By wetting the warp evenly with the sizing solution, Esterol, it is claimed, promotes high slasher speeds and greater loom efficiency in the warp-sizing of rayons. When Esterol is used in the fulling of worsteds, prior desizing is said to be unnecessary and subsequent scouring is facilitated. The folder also suggests other useful applications of Esterol, all of which have been proved under exacting mill conditions.

A copy of the folder may be obtained by writing on your business stationery to the Textile Chemicals Division, L. Sonneborn Sons, Inc., 88 Lexington Avenue, New York 16, N. Y.

● **BOOKLET ON MELAMINE**

A 24-page illustrated booklet describing the many applications of the chemical melamine, in the plastics, textile, paper, leather, chemical, paint and allied industries, has been published by the American Cyanamid Company.

The booklet is designed for popular appeal and supplements the numerous technical publications relating to the various applications of melamine and the chemical compounds in which it is used.

Among the more important applications of melamine are its use in plastics of high arc resistance; in wet-strength paper; in the shrinkage control of wool; in making improved leather, and especially leathers which are white all the way through; in water repellents for fabrics; in improved enamels suited to mass production of automobiles and household appliances, and in the production of the chemical equivalent of distilled water. Copy of the booklet will be sent by request.

• CLASSIFIED ADVERTISEMENTS •

The rate for "Position Wanted" advertisements in this column is 2 cents a word—with a minimum of 50 cents per insertion. For all other types of advertisements—i.e., help wanted, machinery or supplies for sale—the rate is $6.25 per column inch or less per insertion.

POSITION WANTED: Hosiery Dyer, with several years experience both technical and practical, capable of handling any hosiery dye job. Not employed as dyer at present. Box 654.

POSITION WANTED: Supt. Dyer, college graduate, 25 years' experience, cotton and rayon yarns, all types machines and colors. Good production man. Also consider sales, demonstration of dyestuff or textile finishes. Box 699.

WANTED: RESEARCH CHEMIST; Asst. to Chief Research Chemist. Large textile mfg. company in Newark, N. J., has opening for graduate chemist or chemical engineer. Good post-war opportunity. In reply give age, scholastic background, experience, draft status and salary expected. Write Box 706.

POSITION WANTED: Colorist or head of color laboratory. Seven years technical and plant experience. Married. Locate anywhere. Box 712.

WANTED: Textile Chemist with good background in organic chemistry for research on textile finishes. Essential work. Excellent postwar prospects. Progressive Company. Location New England. Young man 25-35 years old preferred. Write full details. Box 715.

WANTED MALE HELP: Large hosiery Company in Philadelphia is seeking an experienced chemist who can also qualify for physical testing. Unusual opportunity. Box 716.

WANTED: Garment Dyer to Assist Foreman.
Loebl Dye Works, Inc.,
346-350 W. Salem Ave., Roanoke, Va.

WANTED: Research Chemist for work in fields of resins and pigments. Excellent laboratory facilities, ample opportunity for advancement. Location near New York. Send snapshot with record of training and experience. Box 718.

POSITION WANTED: Textile Chemist doing research and development work for a textile manufacturing company on printing, finishing, and plastic coating seeks responsible position in or near New York. Now employed elsewhere. Box 719.

POSITION WANTED: Textile School graduate with 15 years' experience in all phases of wet processing skeins on the general run of machines. Capable of assuming full charge of dye laboratory, dyeing, bleaching and drying, handling cotton, rayon, silk and nylon. Familiar with all types of dyestuff. Box 720.

WANTED: Chemist for research on photographic sensitizing dyes and allied compounds. Good opportunity for man capable of initiating research in this field. Apply, stating age, previous experience and salary desired to R.S.P., Box 3, Newton, N. J.

WANTED: Scott Inclined Plane Serigraph Model I.P. 2 Tensile Testing Machine. Box 721.

Chemical company in metropolitan New York area has opening for a textile chemist familiar with research and development on water repellents, shrink proofing, and applications of resins in the textile field. Box 722.

USE
REPORTER CLASSIFIEDS
FOR RESULTS!

NOTE

Essential employees need release statement. Employees who are to be hired for critical occupations need release statement and U. S. E. S. consent.